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A COMPARISON OF THE EFFECTIVENESS OF A CONTINUOUS LUMBAR EPIDURAL INFUSION OF PRESERVATIVE FREE MORPHINE WITH A CONTINUOUS THORACIC EPIDURAL INFUSION OF 0.0625% BUPIVACAINE PLUS FENTANYL IN PROVIDING POST-THORACOTOMY ANALGESIA

By

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A Thesis

Submitted in partial fulfillment

of the requirements for the degree of

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ABSTRACT

Controversy exists as to which epidural approach, thoracic or lumbar, provides more effective post-thoracotomy analgesia. This quasi-experimental study compared the analgesic efficacy of these two approaches using site appropriate analgesics based on their pharmacokinetic profiles. The investigators hypothesized that there would be no difference in the post-thoracotomy analgesia provided by the lumbar epidural approach using preservative-free Morphine as compared to the thoracic epidural approach using Bupivacaine 0.0625% with Fentanyl.

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The results of this study showed no statistically significant differences between the thoracic and lumbar epidural groups. Furthermore, data indicated that both the thoracic and lumbar epidural approaches provided subjects with adequate post-thoracotomy analgesia. The investigators concluded that it is possible to control post-thoracotomy pain with the lumbar epidural approach and that both approaches should be considered when managing post-thoracotomy analgesia. It is recommended that anesthesia care providers who are not proficient in the thoracic approach should consider using the lumbar approach for post-thoracotomy analgesia.

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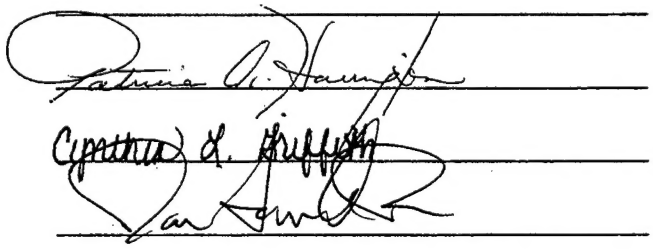

THE UNIVERSITY OF TEXAS
HOUSTON
HEALTH SCIENCE CENTER

The Committee for the
Protection of Human Subjects

NOTICE OF APPROVAL TO BEGIN RESEARCH January 16, 1998

HSC-SN-98-003 - "Evaluation of the Effectiveness of a Continuous Lumbar Infusion of Preservative Free Morphine as Compared to Continuous Thoracic Epidural Infusion of 0.0625% Bupivacaine plus Fentanyl in Providing Post Thoracotomy Analgesia"
PI: CPT James R. Williams, AN/SRNA; et al

PROVISIONS: Unless otherwise noted, this approval relates to the research to be conducted under the above referenced title and/or to any associated materials considered at this meeting, e.g. study documents, informed consents, etc.

APPROVED: At a Convened Meeting

APPROVAL DATE: January 16, 1998 **EXPIRATION DATE**: December 31, 1998

CHAIRPERSON: Anne Dougherty, MD 1/16/98

Subject to any provisions noted above, you may now begin this research.

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CHAPTER 1

Introduction

The significance of postoperative pain is well appreciated. According to Lubenow, McCarthy, and Ivankovich (1992), nearly 75% of hospitalized patients remain in moderate to severe pain despite routine analgesic measures employed. One procedure associated with a significant degree of postoperative pain is a thoracotomy. Epidurals are routinely employed to provide post-thoracotomy analgesia. These may be placed in either the thoracic or lumbar epidural space. Both sites are currently advocated for use in post-thoracotomy pain management. However, controversy exists as to whether comparable post-thoracotomy analgesia can be achieved by the thoracic and lumbar epidural approaches.

By virtue of the epidural anatomy, thoracic epidural catheter placement is said to require greater expertise than lumbar epidural catheter placement (Bromage, 1978). The difficulty associated with thoracic epidural catheter placement creates the potential for an increased incidence of complications with this approach. These complications include hematoma, venous cannulation, catheter breakage, and nerve injury. In addition, the presence of the spinal cord in this region introduces the risk of injury if an inadvertent dural puncture occurs (Cousins & Bridenbaugh, 1988). Other serious complications more commonly associated with the thoracic epidural approach are central and adrenal medullary sympathetic blocks (Cousins & Bridenbaugh, 1988). These blocks may result in a markedly decreased ability of the patient to sustain adequate heart rate and cardiac output, in which case the anesthesia care provider must assume control of the circulation

by employing extensive pharmacologic and physiologic measures (Cousins & Bridenbaugh, 1988). Although the anesthesia care provider can employ measures to maintain hemodynamic stability, these external measures cannot compare to the body's own regulatory mechanisms (Cousins & Bridenbaugh, 1988).

Despite the potential complications associated with thoracic epidurals, some researchers continue to hold this approach in high regard (Sawchuck, Ong, Unruh, Horan, & Greengrass, 1993). Specifically, researchers have documented that thoracic epidurals have superior analgesia, lower narcotic requirements, and fewer associated side effects when compared to the lumbar epidural approach (Bodily, Chamberlain, Ramsey, & Olsson, 1989). Other researchers have documented that thoracic epidurals are associated with significantly shorter hospital stays, improved postoperative pulmonary function tests, and quicker return of bowel function when compared to the lumbar epidural approach (Guinard, Mavrocordatos, Chiolero, & Carpenter, 1992).

In contrast to thoracic epidural catheters, lumbar epidural catheters are considered relatively easy to place. In addition, the majority of anesthesia care providers have a greater degree of expertise in lumbar epidural catheter placement. The complication most commonly associated with epidural placement at the lumbar level is temporary loss of bladder tone. This results from blockade of nerve impulses from sacral segments (Cousins & Bridenbaugh, 1988). Another complication is the possible need for increased doses of analgesics to achieve effective pain relief following some surgical procedures such as a thoracotomy. However, according to some researchers, altering the medications administered at the lumbar site can result in effective analgesia without a

greater incidence of side effects (Fromme, Steidl, & Danielson, 1985; Grant, Boyd, Zakowski, Turndorf, & Ramanathan, 1993; Guinard et al., 1992).

The possibility of providing adequate post-thoracotomy analgesia using an approach that minimizes patient risk was the impetus for this study. The literature is replete with information regarding postoperative epidural analgesia. Reports regarding an optimal approach of epidural analgesic administration for post-thoracotomy pain management remain conflicting. Despite the previous research cited, many investigators continue to find no difference between the thoracic and lumbar epidural approaches with regard to quality of pain relief achieved (Fromme et al., 1985; Grant et al., 1993; Guinard et al., 1992). In addition, some have found no significant differences in incidence of side effects or complications when comparing the two sites (Coe, Sarginson, Smith, Donnelly, & Russell, 1991). In an attempt to identify an ideal drug and method of administration, many researchers have evaluated epidural approaches using the same analgesic. No studies comparing the lumbar and thoracic epidural sites using analgesics specifically tailored to each site have been done. By virtue of the anatomic differences between the sites and pharmacokinetic variation in medications, a unique action can be expected depending on which analgesics are administered and which approach is used. In this study, the investigators considered these differences by administering site appropriate agents to evaluate analgesic efficacy. The investigators administered preservative-free Morphine via the lumbar epidural approach and 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic approach.

Statement of the Problem

Will the administration of a continuous infusion of preservative-free Morphine via the lumbar epidural approach provide effective analgesia as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients?

Conceptual Framework

The conceptual framework for this study was based on Sister Callista Roy's adaptation model (Galbreath, 1995). Roy considers a person to be an adaptive system in a constantly changing environment. Adaptive "means that the human system has the capacity to adjust effectively to changes in the environment and, in turn, affects the environment" (Andrews & Roy, 1991, p. 7). Based on the current level of adaptation, a person adapts to changes in the environment by using internal processes--input, throughput, and output. These internal processes are composed of interdependent parts acting in unity. These interdependent parts provide a person with the ability to adapt to change. A positive response is called an adaptive response. "Adaptive responses are those that promote the integrity of the person" (Galbreath, 1995, p. 255). In terms of the goals of adaptation, ineffective responses are "those that neither promote integrity nor contribute to the goals of adaptation. That is, they may, in the immediate situation or if continued over a long time, threaten the person's survival, growth, reproduction, or mastery" (Andrews & Roy, 1991, p. 12).

The investigators conceptualized a thoracotomy as placing a demand on a patient that taxes their ability to adapt; this can result in an ineffective response (see Figure 1). The

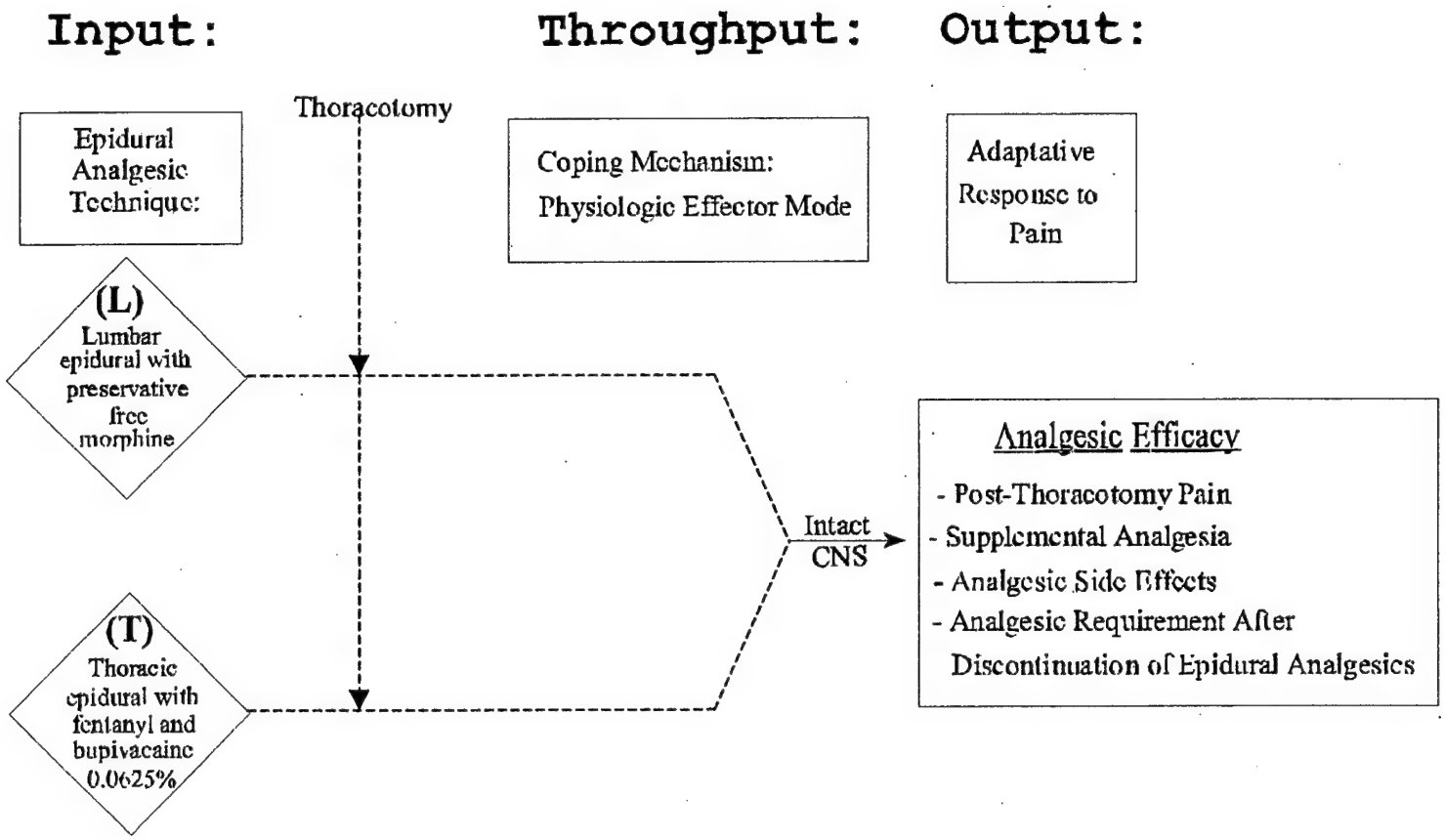


Figure 1. Conceptual model

input of the epidural analgesic technique augments a patient's coping mechanism, specifically the physiologic effector mode of sensation. The two epidural analgesic techniques used in this study were a continuous infusion of preservative-free Morphine via the lumbar epidural approach and a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach. The investigators compared the adaptive response of patients who received analgesia via the lumbar epidural approach with those who received analgesia via the thoracic epidural approach. The adaptive response to pain was defined as a tolerable level of discomfort without undue side effects or increased requirements for analgesics. Properties of the drugs were evaluated as they relate to ineffective responses. Drug properties evaluated were analgesic side effects, the need for supplemental analgesia, and the analgesic requirement after discontinuation of epidural analgesics.

Input

According to Roy's adaptation model, inputs are identified as internal and external stimuli. The major input of interest in the framework for this study was the epidural analgesic technique used for a thoracotomy procedure. A thoracotomy was defined as a procedure above the diaphragm where the thoracic cavity is surgically manipulated. A thoracotomy causes pain impulses to travel up the spinal cord to the central nervous system via afferent nerve fibers (A-delta and C fibers). Once these impulses reach the central nervous system, the perception of pain occurs. The epidural analgesic technique is used for pain management. This technique consists of the administration of medications into the epidural space to provide post-thoracotomy analgesia, which

facilitates the patient's adaptive response to pain. In this study, the analgesic technique consisted of either a lumbar epidural with preservative-free Morphine or a thoracic epidural with 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

Throughput

The ability of humans to adapt to input requires the use of throughput subsystems. According to Roy, these subsystems include learned and inherited coping mechanisms and effector modes. Coping mechanisms are learned and inherited control processes that coordinate responses to stimuli with the appropriate effector modes. The regulator is the coping mechanism that coordinates responses to stimuli affecting basic physiologic functions of the body. In contrast, the cognator coordinates responses to stimuli related to higher brain functions (Andrews & Roy, 1991).

Effector modes, also called adaptive modes, are groups of behaviors or responses used in adapting to stimuli. Effector modes are divided into four categories: physiologic function, self-concept, interdependence, and role function. Physiologic function and self-concept have the most relevance to anesthesia practice. The physiologic function mode controls innate responses such as heart rate, blood pressure, body temperature, and waste elimination. The self-concept mode controls conscious perception of and response to pain. Normal functioning of throughput processes requires intact nervous pathways between various control centers of the brain (Andrews & Roy, 1991).

The physiologic adaptive mode encompasses: oxygenation, nutrition, elimination, activity and rest, skin integrity, senses, fluids and electrolytes, neurological function, and endocrine function (Galbreath, 1995). The framework used in this study focused on the

physiologic adaptive mode as it relates to the senses. Pain sensation is transmitted via afferent nerve fibers from the periphery to the dorsal horn of the spinal column. At this synapse, mu receptors modulate presynaptic and postsynaptic impulses. The expected result of this modulation is a decreased perception of pain (Cousins & Brindenbaugh, 1988).

Morphine and Fentanyl both act at mu receptors on the spinal cord (Reisine & Pasternak, 1996). The pharmacokinetic and pharmacodynamic properties of these drugs are different. In the cerebrospinal fluid, Morphine spreads to the central areas of the brain (periaqueductal gray area) and acts at kappa receptors to modulate pain perception centrally. Fentanyl has a segmental spread. This segmental spread results in Fentanyl primarily acting at spinal cord mu receptors; therefore the placement of a Fentanyl infusion should be placed near the operative dermatome level for analgesia (Hurford, Dutton, Alfille, Clement, & Wilson, 1993). The addition of Bupivacaine to the thoracic epidural infusion of Fentanyl has been recommended to increase the analgesia and decrease the amount of Fentanyl required for postoperative analgesia efficacy (Liu, Angel, Owens, Carpenter, & Isabel, 1995; Paech & Westmore, 1994). Both Morphine and Fentanyl with Bupivacaine modulate neuronal transmission resulting in decreased pain sensation. The input of the epidural analgesic technique allows for augmentation of throughput by receptor modulation and the output of an adaptive response to pain.

Output

According to Roy, input is channeled through coping mechanisms and effector modes to produce output behavior. Output behavior may be observed, measured, or

subjectively reported (Galbreath, 1995). Roy categorizes output as adaptive and ineffective responses. An adaptive response is consistent with goals of survival and growth. An ineffective response does not allow a person to achieve the goals of survival and growth (Galbreath, 1995). Andrews & Roy (1991) explained that these responses "act as feedback or further input to the system, allowing the person to decide whether to increase or decrease efforts to cope with stimuli" (pp. 7-8).

In the framework for this study, adaptive response to pain was the desired output. The patient's adaptive response to pain was defined as a tolerable level of discomfort without undue side effects or increased requirements for analgesics. The adaptive and ineffective responses to pain were evaluated by the following output behaviors: post-thoracotomy pain level, supplemental analgesia required, analgesic side effects, and analgesic requirement after discontinuation of epidural analgesics. The output of post-thoracotomy pain was defined as an unpleasant sensory and emotional experience associated with actual tissue damage from a thoracotomy procedure (AHCPR, 1992). Supplemental analgesia was defined as the modulation of neuronal transmission to facilitate patients' adaptive response to pain by decreasing their perception of pain. Analgesic side effects were defined as secondary and usually adverse effects of an analgesic that contributed to a patient's ineffective pain response. Evaluation of side effects allowed for a more accurate interpretation of a patient's adaptation level. Analgesic requirement after discontinuation of epidural analgesics was defined as the continued modulation of neuronal transmission related to pharmacokinetic properties of the analgesic technique to facilitate patients' adaptive response to pain after the epidural

analgesic is discontinued. Pharmacokinetics can be described using a three-compartment model. Morphine has a 15 - 60 minute onset of action, peaks in 90 minutes, and has a 6 - 24 hour duration of action. Bupivacaine has a 4 - 17 minute onset of action, peaks in 30 - 45 minutes, and has a 3.3 - 6.7 hour duration of action. Fentanyl has a 4 - 10 minute onset of action, peaks in 20 minutes, and has a 2.6 hour duration of action. (Reisine & Pasternak, 1996). Therefore the adaptive response facilitated by the lumbar epidural preservative-free Morphine group was expected to be longer than the response facilitated by the thoracic epidural group with 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

In summary, the investigators used a framework based on Roy's adaptation model to compare the effectiveness of two types of anesthetic techniques in providing post-thoracotomy analgesia. According to the framework, the input of the epidural analgesic technique acts in conjunction with the throughput, which includes the patient's learned and inherited coping mechanisms. The expected output is modulation of neuronal transmission and thus an adaptive response to post-thoracotomy pain. A patient's adaptive response to pain was measured by post-thoracotomy pain level, requirement for supplemental analgesia, analgesic side effects, and analgesic requirement after discontinuation of epidural analgesics.

Purpose

The purpose of this study was to evaluate the analgesic efficacy of a continuous infusion of preservative-free Morphine via the lumbar epidural approach as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the

thoracic epidural approach in post-thoracotomy patients. The investigators compared the lumbar and thoracic approaches using site appropriate analgesics currently used by the Anesthesia and Operative Service at an Army regional medical center in the southeastern United States.

Definition of Terms

Epidural Analgesia Technique

Conceptual definition. The administration of medications into the epidural space to facilitate the patient's adaptive response to pain.

Operational definition. The continuous infusion of 0.0625% Bupivacaine Hydrochloride and Fentanyl 5 mcg/cc via the thoracic epidural route or the continuous infusion of preservative-free Morphine 0.1 mg/cc via the lumbar epidural route to attenuate or abolish post-thoracotomy pain.

Post-Thoracotomy Pain

Conceptual definition. An unpleasant sensory and emotional experience associated with actual tissue damage from a thoracotomy (AHCPR, 1992).

Operational definition. An unpleasant sensory and emotional experience associated with actual tissue damage from a thoracotomy as assessed by the Visual Analog Scale.

Supplemental Analgesia

Conceptual definition. Modulation of neuronal transmission to facilitate patients' adaptive response to pain by decreasing their perception of pain.

Operational definition. The administration of an epidural bolus, epidural rate increases, and or intravenous analgesic boluses to modulate patients' perception of pain as recorded on the Epidural Analgesia Data Tool (see Appendix A).

Analgesic Side Effects

Conceptual definition. Secondary and usually adverse effects of an analgesic that contributed to a patient's ineffective pain response.

Operational definition. Secondary and usually adverse effects of analgesic medications including but not limited to pruritus, nausea, vomiting, urinary retention, and respiratory depression as ascertained by patients' physical exam at preset evaluation periods.

Analgesic Requirement After Discontinuation of Epidural Analgesics

Conceptual definition. The continued modulation of neuronal transmission related to pharmacokinetic properties of the analgesic technique to facilitate patients' adaptive response to pain after the epidural analgesic is discontinued.

Operational definition. The documented time of first patient request for analgesic administration after discontinuation of epidural analgesics as recorded on the Epidural Analgesia Data Tool.

Research Question

Will a continuous infusion of preservative-free Morphine via the lumbar epidural approach provide effective post-thoracotomy analgesia as compared to a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl?

Hypotheses

1. Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in post-thoracotomy pain while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

2. Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in the requirement for supplemental analgesia while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

3. Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic side effects while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride and Fentanyl.

4. Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic requirement after discontinuation of the epidural analgesics than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

Significance

Of the two methods for providing post-thoracotomy analgesia, the thoracic epidural approach is inherently more difficult and is associated with greater potential risk to the patient (Bromage, 1978). Despite the potential risk, some anesthesia care providers continue to favor the thoracic approach, citing it as more effective in providing post-thoracotomy analgesia. Studies comparing the lumbar and thoracic approach using the same medications are conflicting with regard to the most efficacious approach for epidural opioid administration for post-thoracotomy analgesia, and no studies comparing the two routes with site appropriate drugs have been reported. A better comparison of the effectiveness of these two approaches in providing post-thoracotomy analgesia would enable anesthesia care providers to make appropriate decisions when selecting an approach for epidural analgesia administration for their patients.

Assumptions

Assumptions of the study were as follows:

1. All thoracotomy patients who participated in this study had a functioning epidural.

2. ASA classifications adequately identified patients' general health status.

3. Records that the nursing staff maintained regarding epidural infusions accurately reflected the amount of a drug administered.

Limitations

Limitations of the study were as follows:

1. Because randomization of the patient population could not be obtained in this study, the investigators could not generalize the results to post-thoracotomy patients outside their sample.

2. The sample was obtained only from patients who were eligible for medical care at a military hospital.

3. Pain was subjective and varied among members of the sample due to differences in the subjects' gender, age, and ethnicity.

4. The sample size was limited by the number of subjects who presented to the data collection site for a thoracotomy procedure during the period of data collection.

Summary

Anesthesia care providers can contribute to the speed and quality of patient recovery by effectively and safely managing postoperative pain. Epidural analgesia appears to be the most advantageous means of controlling post-thoracotomy pain (Bromage, 1978). Of the two available means of providing epidural analgesia, the thoracic approach poses a greater risk of complications (Bromage, 1978). The review of literature was inconclusive as to which approach, if any, provides analgesia that is more effective. In addition, the investigators did not find a comparison of the thoracic and lumbar epidural approaches using site appropriate analgesics in the literature. By measuring patients' perceived level of pain, requirements for supplemental analgesics, incidence of side effects, and the time to first analgesic requirement after discontinuation of epidural analgesics, the

investigators proposed to compare the analgesic efficacy of the lumbar and thoracic epidural approaches using site appropriate analgesics. If anesthesia care providers had more options for providing effective post-thoracotomy analgesia, they would be better prepared to help patients adapt to their surgical procedure and return to an optimal level of functioning.

CHAPTER II

Review of Literature

The investigators did not find a comparison of the thoracic and lumbar epidural approaches using site appropriate analgesics in the literature. However, a large quantity of material has been published comparing the lumbar and thoracic epidural approaches using the same medication. In this review, the investigators present a brief overview of pain followed by epidural anatomy, epidural analgesia, complications of catheter placement, medications, and side effects.

Pain

Pain, as described by the International Association for the Study of Pain, is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Ready, 1994, p. 2327). Pain associated with surgery is believed to result from the local release of pain promoting mediators in response to induced tissue damage and the production of noxious stimuli transmitted to the neuraxis via A-delta and C nerve fibers. Depending on their precise destination within the central nervous system (CNS), these noxious stimuli provoke either segmental reflex or supra-segmental and cortical responses (Ready, 1994). According to Ready (1994), included among the segmental reflex responses are increased skeletal muscle tone, spasm, consequent increase in lactic acid production, and oxygen consumption. The resulting sympathetic stimulation produces tachycardia, increased stroke volume and myocardial oxygen consumption. Supra-segmental reflex responses also increase sympathetic tone and stimulate increased hypothalamic functioning. Hypothalamic

stimulation results in increased body metabolism with further increases in oxygen consumption. Cortical responses are associated with noxious stimuli reaching the highest brain centers. In awake patients, this may be manifested as heightened apprehension and anxiety, which further stimulate increased hypothalamic activity (Ready, 1994).

The adverse effects associated with postoperative pain are many and may be the primary contributors to post surgical morbidity and mortality. These effects may be classified as both physiological and psychological. Physiological changes are most evident in the cardiovascular, respiratory, gastrointestinal, urinary, and neuroendocrine systems. Psychological effects of pain are manifested in many ways and can equally contribute to the patient's overall condition and quality of post surgical recovery (Ready, 1994).

Besides the effects on the body systems, pain also elicits changes elsewhere in the body. The sympathetic activation that occurs with pain causes an overall decrease in immune system functioning. Activation of the stress response results in leukocytosis and decreased functioning of the reticuloendothelial system. These changes contribute to a lowering of the patient's resistance and increased potential for infection. Sympathetic activation may also cause changes in blood coagulability. These changes include increased platelet adhesiveness and decreased fibrinolysis, both of which contribute to a hyper-coagulable state increasing the risk of thromboembolism (Lubenow et al., 1992).

Epidural Anatomy

The epidural space is found between the dura mater (the covering of the spinal cord and nerve roots) and the connective tissue covering the vertebrae. The contents of the

epidural space vary depending on the level of the vertebral spinal column. In the thoracic region, nerve roots enter the epidural space at their approximate level of origin. The nerve roots are quite slender as compared to the thicker lumbar roots. For these reasons, medications injected into the epidural space will be effective to varying degrees. Their effect will be dependent on the precise level at which they are injected as well as the pharmacokinetics of the drug (Bromage, 1978). The anatomy of the vertebrae also varies with respect to the level of the spinal column. Inserting a thoracic epidural needle is technically more difficult than inserting a lumbar epidural needle due to the acute angle of the thoracic spinous processes. In the thoracic region, the spinous processes sit closer together and exhibit a greater downward angulation. In the lumbar region, the spinous processes appear almost horizontal. According to Bromage (1978), the distance between the ligamentum flavum and the dura at L2 is 5 - 6 mm. In the thoracic region, the distance between the ligamentum flavum and the dura is 3 - 5 mm. Because the epidural space in the thoracic region is narrower when compared with the lumbar region, greater potential for direct spinal cord injury exists.

The principal site of action of epidural anesthesia is on the afferent impulses at the nerve roots, dorsal root ganglia and opioid receptors in the substantia gelatinosa. Local anesthetics in clinical concentrations provide effective analgesia as the sole agent. However, the total dose and initial bolus dose of the local anesthetic may produce undesirable side effects of hypotension and sensorimotor blockade. To provide analgesia and limit these side effects, a combination of dilute local anesthetic and opioid

administered continuously in an epidural catheter is advocated. In this way, interrupting nociceptive pathways can produce a synergistic effect (Cousins & Bridenbaugh, 1988).

Epidural Analgesia

The review of literature is inconclusive about the analgesic effectiveness of thoracic versus lumbar epidural infusions. While some evidence suggests that epidural catheter location has little influence on the quality of analgesia, some researchers suggest superior pain control and lower epidural requirements of narcotics in patients receiving thoracic versus lumbar epidurals (Bodily et al., 1989). Other researchers document shorter hospital stays, improved postoperative pulmonary function tests, or quicker return of bowel function in patients receiving thoracic versus those receiving lumbar epidurals (Guinard et al., 1992).

Bodily et al. (1989), in their comparison of the thoracic versus lumbar epidural approach for post-thoracotomy analgesia ($n = 32$), found that thoracic epidural Fentanyl provided better post-thoracotomy analgesia at a lower dose than lumbar epidural Fentanyl. In contrast, Guinard et al. (1992) found no significant difference in analgesic effect between these two approaches when comparing Fentanyl for post-thoracotomy pain management. In a study comparing thoracic versus lumbar epidural approaches for post-thoracotomy analgesia, Sawchuck et al. (1993) were unable to show differences in the overall quality of analgesia achieved. However, the thoracic epidural group required less Fentanyl administration than the lumbar epidural group ($p < 0.05$). These findings were also reported by Hurford et al. (1993) when they compared thoracic and lumbar epidural approaches with Bupivacaine and Fentanyl for post-thoracotomy pain

management, with the exception that they noted "an increased infusion rate was required in the lumbar epidural group to achieve equivalent analgesic levels." (Hurford et al., 1993, p. 337). However, Coe et al. (1991) did not show a superior approach of epidural analgesic administration when comparing thoracic and lumbar epidural Fentanyl for post-thoracotomy pain management. These investigators found no difference between the analgesic effects of lumbar and thoracic epidural Morphine in controlling postoperative pain.

Complications of Catheter Placement

Several complications are associated with the thoracic and lumbar approaches to epidural catheter placement. Bromage (1989) reported that potentially dangerous complications exist with thoracic epidural cannulation. The most severe complication is spinal cord injury. The T5 - T6 interspace is frequently used for the thoracic approach and is the narrowest of vertebral interspaces. The acute angulation of this region coupled with its narrow interspaces makes thoracic epidural catheter placement more difficult than the lumbar epidural approach. This presents the potential for a dural puncture and an increased risk of spinal cord injury. The risk for spinal cord injury is said to exist whenever an epidural needle is inserted above L2, the level at which the spinal cord ends (Fromme et al., 1985).

Cousins and Bridenbaugh (1988) studied the actual incidence of spinal cord injury following thoracic epidural cannulation. They stated that most cases of serious neurological sequelae occur in small hospitals or after an epidural block is attempted by an inexperienced anesthesia care provider. Despite the minor incidence of direct spinal

cord injury that is associated with the thoracic approach, the potential for serious neurological sequelae still exists.

The lumbar approach to epidural analgesia is associated with a negligible risk for spinal cord injury. Because the spinal cord ends at the level of the T12 - L1 vertebrae, lumbar epidural cannulation at the level of L2 and below is not associated with this potential complication. In addition, placement of a lumbar epidural catheter is considered technically less challenging than the thoracic approach due to the anatomic variations previously mentioned (Cousins & Bridenbaugh, 1988).

Medications

Bupivacaine Hydrochloride

Bupivacaine is an amide local anesthetic introduced into practice in 1963. The action of local anesthetics is to selectively block the increase in sodium permeability and prevent action potential propagation. Local anesthetics cause the sodium channel to be functionally fixed in the inactivated state, thus reducing inward sodium current. Bupivacaine is similar in chemical structure to lidocaine but is more potent and has a longer duration of action. Pharmacokinetics can be described using a three-compartment model. Bupivacaine is 95% protein bound, has a half-life of 2.4 hours, and is toxic in blood concentrations greater than 1.6 mcg/ml. (Reisine & Pasternak, 1996).

Fentanyl

Fentanyl is a synthetic opioid considered 80 times more potent than morphine in providing analgesia. Fentanyl's action is primarily accomplished by interacting as a mu agonist in the substantia gelatinosa of the spinal column. Fentanyl is a lipophilic agent

that tends to provide a more segmental analgesic effect than agents such as preservative-free Morphine, which is not as lipophilic. In the spinal cord, Fentanyl binds to epidural fat and diffuses across the dura into the lipid structures of the spinal cord structures, which results in a segmental effect. The segmental analgesic effect requires the placement of an epidural catheter, which is able to cover the dermatome included in the surgical field (Reisine & Pasternak, 1996).

An opioid agonist selectively inhibits various nociceptive reflexes. At least three mechanisms may be involved in the action of opioids. Opioid receptors on the terminals of primary afferent nerves mediate inhibition of the release of neurotransmitters including Substance-P. Fentanyl also antagonizes the effects of exogenously administered Substance-P by exciting postsynaptic inhibitory interneurons. It also antagonizes the output neurons of the spinothalamic tract, which convey nociceptive information to higher centers in the brain. Pharmacokinetics can be described using a three-compartment model. Fentanyl is 84% plasma protein bound, has a 4 - 10 minute onset of action, peaks in 20 minutes, and has a 2.6 hour duration of action (Reisine & Pasternak, 1996).

Paech and Westmore (1994) studied the benefits of adding 0.1% Bupivacaine to a thoracic epidural infusion in the early postoperative period. In their study, two groups of women ($\underline{n} = 40$) scheduled for major abdominal gynecological surgery were randomized in a double blind fashion to receive either a thoracic epidural infusion of Fentanyl and Bupivacaine or a thoracic epidural infusion of Fentanyl only. The Fentanyl and Bupivacaine group experienced better analgesia both at rest and with movement during

the first 24 hours postoperatively as measured by the Visual Analog Scale (VAS).. No significant differences were found between the groups regarding side effects or lower limb weakness. Fentanyl utilization was found significantly lower in the Bupivacaine and Fentanyl group than in the Fentanyl only group (41 vs. 53 mcg/hr). Liu et al. (1995) randomized 24 patients in a double blind study to evaluate which dosage of Bupivacaine would provide the best analgesia with the fewest number of side effects when infused into a thoracic epidural. These researchers compared Fentanyl and saline to Fentanyl plus Bupivacaine 0.1%, 0.05%, and 0.01%. The saline group required 50% more Fentanyl than the other groups. No significant differences were noted between the groups regarding opioid side effects. The investigators reported that the addition of 0.05% Bupivacaine to Fentanyl provided the best analgesia, decreased opioid requirements, and did not have detectable hemodynamic side effects when compared to Fentanyl alone. The results of the study demonstrated that adding 0.05% Bupivacaine to Fentanyl significantly decreased the dose requirement of Fentanyl. George, Wright, and Chisakuta (1991) conducted a prospective, randomized comparison of thoracic ($n = 17$) and lumbar ($n = 16$) epidural infusions of 0.2% Bupivacaine and 10 mcg/ml Fentanyl in an effort to determine which approach would provide the best postoperative pain relief, the most cardiovascular stability, and the least number of side effects. These researchers demonstrated that the thoracic epidural approach provided significantly better analgesia and fewer side effects, including hypotension and respiratory depression, than did the lumbar epidural approach ($p < 0.05$).

Preservative-Free Morphine

Morphine sulfate is an opioid that has various routes of administration. This drug primarily acts as an agonist at mu receptors and has a very potent effect in the spinal cord due to the high concentration of opioid receptors (Reisine & Pasternak, 1996). This high concentration of opioid receptors allows a much smaller dose of Morphine to be administered into the epidural space. The onset of action for Morphine in the epidural space is 15 - 60 minutes, its peak effect occurs in 90 minutes, and its duration of action is 6 - 24 hours (Morgan & Mikhail, 1996). Side effects of preservative-free Morphine still occur, but the incidence is less with the epidural approach than with the parental route. A higher dose of Morphine would be needed parenterally to achieve the same pain control. Parenteral Morphine has an onset of action of 15 - 60 seconds, it has a peak effect of 30 minutes - 1 hour, and it has 4 – 5 hour duration of action (Reisine & Pasternak, 1996). Morphine is a hydrophilic compound, which accounts for its ability to spread cephalad when injected into the epidural space. Once in the epidural space, Morphine penetrates the dura, which results in a concentration of the analgesic in the cerebral spinal fluid (CSF). Because of the hydrophilic nature Morphine possesses, the analgesic follows the rostral spread of CSF and saturates the entire length of the spinal cord. In addition, Morphine interacts with the periaquaductal gray area. Interaction with this area in the brain results in the interruption of action potential to the substantia gelatinosa in the dorsal horn of the spinal column, which results in the modulation of pain. Therefore, preservative-free Morphine can be infused at the lower lumbar level and still provide analgesia for surgical procedures of the thorax (Reisine & Pasternak, 1996).

The pharmacokinetic principles of Morphine enable it to be used in the lumbar epidural space with good results. Fromme et al. (1985) noted that pain control was similar between thoracic and lumbar epidural analgesia with Morphine. They found that only 2 out of 30 patients were not satisfied with their pain control provided by lumbar epidural Morphine. This did not differ statistically from the 5 out of 92 patients who were not satisfied with the pain control provided by their thoracic epidural Morphine. A retrospective study comparing thoracic and lumbar approaches with epidural Morphine found no significant difference in dose requirement or duration of analgesia (Grant et al., 1993). There were also no significant differences in post-thoracotomy pain control, dosage, or side effects between thoracic and lumbar analgesia (Coe et al., 1991).

Side Effects

Epidural catheter placement risk is not the only factor to consider when providing epidural analgesia. Despite the location of the analgesic administered, several side effects may be encountered. The most serious side effect associated with epidural opioid administration is respiratory depression. Respiratory depression can be life threatening and is associated with decreased mentation and confusion. However, in a study by Gustafsson, Schmidt and Jacobsen (1982), the reported incidence of respiratory depression with epidural opioid administration was 0.25% to 0.4%. In addition, the respiratory depression was usually gradual in onset, allowing time for diagnosis and treatment.

Other reported side effects of epidural opioids include urinary retention, pruritus, nausea, and vomiting (Cousins & Bridenbaugh, 1988). These side effects are reported to

occur less frequently than respiratory depression. However, the incidence is increased with a greater opioid dosage. The risk-benefit ratio of increasing dosages rises rapidly once effective analgesia has been achieved (Nordberg, Hedner, & Mellstrand, 1983).

Studies have been conducted addressing the incidence of dose and site specific side effects occurring during epidural analgesia. Saito, Uchida, Kaneko, Nakatani, and Kosaka (1994) compared continuous thoracic epidural infusions of preservative-free Morphine plus Bupivacaine to Fentanyl plus Bupivacaine and studied the associated incidence of side effects of each. Systolic arterial blood pressure below 90 mmHg was found to occur in 73% of the preservative-free Morphine group (PFMG) compared to 45% of the Fentanyl group. Pruritus occurred in 80% of the PFMG compared to 25% of the Fentanyl group. Nausea and vomiting occurred in 20% of the PFMG compared to 15% of the Fentanyl group, while extremity numbness occurred in 8% of the PFMG compared to 5% of the Fentanyl group. None of the 95 subjects studied developed respiratory depression. Urinary retention was not evaluated because all patients received an indwelling urinary catheter. Saito et al. (1994) concluded that patients receiving PFMG experienced a greater incidence of these side effects when compared to those receiving Fentanyl plus Bupivacaine.

Contrasting results were found in a study conducted by Fromme et al. (1985). They compared lumbar versus thoracic epidural administration of preservative-free Morphine for post-thoracotomy pain relief. They found no significant difference in the incidence of respiratory depression, nausea, vomiting, pruritus, hypotension or urinary retention between the two sites. In addition, Fromme et al. (1985) concluded that the respiratory

depression that occurred may not have been related to cerebral spinal fluid levels of opioids in the brain, but may have resulted from increased patient sensitivity to opioids. The 2% of patients who experienced respiratory depression with epidural morphine were elderly or debilitated or had severe obstructive pulmonary disease. Pflug and Bonica (1977) reported that these types of patients are known to have increased susceptibility to narcotic induced side effects related to their debilitated state.

Coe et al. (1991) compared lumbar epidural Fentanyl to thoracic epidural Fentanyl for post-thoracotomy pain management. Differences in side effects between the two groups were reported as statistically insignificant. These researchers reported that little justification existed to use the less familiar and potentially more dangerous thoracic approach when Fentanyl alone is used to provide postoperative analgesia.

Summary

The literature clearly supports epidural analgesia as an effective means of controlling postoperative pain. Most researchers suggest that the location of the epidural analgesic technique has minimal influence on the quality and degree of pain relief. Some researchers, however, cite better pain control, lower epidural dose requirements of opioids, and fewer side effects with the thoracic epidural approach than with the lumbar epidural approach. Researchers thus far, whether supporting or refuting the idea of an analgesically optimal route of administration, have made comparisons of the two approaches using the same drug. The literature currently does not include a comparison study of the two approaches using drugs specifically tailored to each site. The lack of comparison between the thoracic and lumbar epidural approach using site appropriate

drugs represented a major limitation in the current literature. The purpose of this study was to evaluate the analgesic efficacy of a continuous infusion of preservative-free Morphine via the lumbar epidural approach as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients.

CHAPTER III

Methodology

The purpose of this study was to evaluate the analgesic efficacy of a continuous infusion of preservative-free Morphine via the lumbar epidural approach as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients. The investigators compared the two approaches using site appropriate analgesics currently used by the anesthesia and operative service at an Army regional medical center. The thoracic epidural analgesic administered was Bupivacaine Hydrochloride 0.0625% plus Fentanyl 5 mcg/cc. The lumbar epidural analgesic administered was preservative-free Morphine 0.1 mg/cc. The study design was quasi-experimental. In this chapter, the investigators address the various aspects of methodology to include: population, setting, sample, instrumentation, protection of human subjects, data collection, study design, and data analysis.

Population, Setting, and Sample

The sample for this study was selected from subjects who were scheduled for a thoracotomy procedure and agreed to an epidural for post-thoracotomy analgesia at the data collection site between December 1997 and September 1998. Thoracotomy was defined as a surgical procedure above the diaphragm where the thoracic cavity is surgically manipulated. Thoracotomies performed at the data collection site included video assisted thoracic surgeries, lung resections, esophagectomies, pneumonectomies, xyphoidectomies, chest wall resections, thoracic aneurysm repairs, rib resections, and thoracoplasties. At the time of the study, the data collection site was a 150-bed Army

regional medical center in the southeastern United States, and approximately 5,000 surgical procedures were performed at this medical center annually. Approximately 139 thoracotomies were performed at this site in the 18 months prior to the initiation of data collection. Included in the sample were subjects who were (a) scheduled for a thoracotomy during the time of data collection, (b) had consented to participate in the study, (c) were between 18 and 80 years of age, (d) were legally competent to give consent, (e) were English speaking, and (f) were in class I, II, III, or IV of the American Society of Anesthesiologists (ASA) rating system. The ASA classification is used to communicate patients' general health status. Patients in ASA class I have no systemic disease; patients in ASA class II have mild to moderate systemic disease which is not lifestyle limiting; patients in ASA class III have moderate to severe systemic disease which is lifestyle limiting, but is not a daily threat to life; and patients in ASA class IV have severe systemic disease that is a constant threat to life (Morgan & Mikhail, 1996).

Excluded from the sample were subjects with one or more of the following conditions: coronary artery bypass grafting, emergency surgery, pregnancy, history of allergy to one of the study agents, or any one of the specified absolute or relative contraindications for receiving epidural catheter placement. Absolute contraindications include patient refusal, sepsis with hemodynamic instability, uncorrected hypovolemia, and coagulopathy. Relative contraindications include a history of neuromuscular disease, previous spinal cord injury, peripheral neuropathies, elevated intracranial pressure, chronic back pain, and local infection at the epidural site. Non-English speaking patients

were excluded due to the lack of interpreter availability at all times when data were being collected.

Considering previous studies using an epidural for postoperative pain control, the investigators estimated that a medium effect size (0.8) was adequate to evaluate the differences between the epidural anesthetic approaches. The chance of random error in this study was set at 0.05 (alpha). With an estimated power of 0.80, a sample size of 30 subjects in each group (thoracic and lumbar epidural) was determined to be sufficient to offset missing data and subject attrition (Polit & Hungler, 1995).

Instrumentation

Epidural Analgesia Data Tool

The Epidural Analgesia Data Tool was developed from the review of literature and was based on the conceptual framework for this study. The Epidural Analgesia Data Tool was used to document demographic data as well as data on the subjects' epidural insertion, infusion rate, need for supplemental analgesics, and time to first analgesic requirement after discontinuation of the epidural analgesics (see Appendix A). Other data included on the Epidural Analgesia Data Tool were used for data analysis.

Epidural Narcotic Analgesia Flowsheet

The investigators obtained information for the Epidural Analgesia Data Tool from an overprint on DA Form 4700, Epidural Narcotic Analgesia Flowsheet (see Appendix B). This form is a flowsheet used at the data collection site to track information on each patient receiving epidural analgesia outside of the operating room. Included on this form are all of the following: analgesia bolus (intravenous or epidural), total volume delivered,

sedation level, analgesia level, and side effects. All of these data were assessed and documented each hour by the assigned nurse in the surgical intensive care unit (SICU) or post anesthesia care unit (PACU) or on the ward. The investigators used this form to determine whether any additional epidural or parental medications were utilized for pain control and to gather information about the subjects' side effects.

Medication Administration Record

In addition, at the study site ward nurses routinely recorded all supplemental analgesics given to patients on the Medication Administration Record (see Appendix C). At each data collection point, the investigators compared information recorded on the Medication Administration Record with information recorded on the Epidural Narcotic Analgesia Flowsheet for all subjects. Any discrepancies between the two forms were clarified with the ward nurse assigned to the subject. The investigators' ability to check the information recorded on both forms enhanced the validity of the data collected.

Visual Analogue Scale

The investigators used the Visual Analog Scale (VAS) to collect data about subjects' postoperative pain level (see Appendix D). This allowed for the comparison of subjects' pain level with the amount of medication required to achieve adequate analgesia. This also allowed for assessment of adequate analgesia during the subjects' postoperative hospital stay.

The VAS is a unidimensional instrument often used by anesthesia care providers in clinical research for assessing the intensity of acute pain (Flaherty, 1996). The VAS uses a 5, 10, or 20-centimeter straight line with verbal descriptors at each end. The length of

the VAS line is usually set at 10 centimeters. The VAS line may be positioned vertically or horizontally, but only one orientation must be selected for a study. Gift (1989) found that the vertical line VAS is easier for the subject to use and is a more sensitive instrument for detecting subsequent changes in pain intensity. The verbal descriptor "No pain" is located below the bottom of a vertical line. The verbal descriptor "Pain as bad as it could be" is located above a vertical line (Flaherty, 1996). The subject is instructed to document his intensity of pain by drawing a line through the VAS line that corresponds with his pain level. Cline, Herman, Shaw, and Morton (1992) recommended enclosing the VAS line and verbal anchors in a lightly shaded box that contrasts with the rest of the page to help the subject focus on the VAS.

Advantages of using the VAS include a simplistic design and ease of application. Because the VAS has few words, the subject's vocabulary level is not as critical a factor as it would be with other pain measurement tools. The VAS may have the anchor words set in large type (e.g., 18 pitch) to allow its use with patients who have impaired vision. The patient medicated for pain generally maintains sufficient manual dexterity to use the VAS. Finally, the VAS produces continuous interval level data amenable to powerful, parametric based testing. The time required for explanation and administration of the VAS is estimated to be less than 5 minutes (Flaherty, 1996).

A disadvantage of using the VAS is the difficulty subjects may have conceptualizing their subjective sensation of pain into a straight line. According to Flaherty (1996), this may be overcome by providing the subject with verbal guidance on use of the tool in addition to written instructions at the top of the scale. Another disadvantage is that the

VAS requires multiple steps. First, the subject marks the scale reflecting his pain intensity; then a clinical measurement of the subject's response is made. Flaherty identified this second step as a potential source for error and also warned against photocopying the instrument. Photocopying could magnify or shrink the VAS scale instrument, causing inaccurate measurement.

Despite the weaknesses associated with the VAS, it has been shown to be both a valid and reliable tool (e.g., Ahles, Ruckdeschel, & Blanchard, 1984; Bondestam et al., 1987; Downie et al., 1978; Ferraz et al., 1990; Seymour, 1982). In addition, this tool is considered sensitive enough to detect subtle changes in a subject's estimation of his pain (Choinière & Amsel, 1996; Revill, Robinson, Rosen, & Hogg, 1976; Seymour, 1982). In 1982, Seymour used an experimental manipulation approach to establish construct validity of the VAS instrument. In his study of 12 subjects, he was able to detect an expected decrease in dental pain after analgesia, using both the VAS and the Numerical Rating Scale ($r = 0.956$, $p < 0.001$). In 1976, Revill et al. established reliability of the VAS in a study evaluating labor pain in 20 women. Revill et al. (1976) reported a significant correlation between the subject's initial and 5 minute scores ($n = 20$, $r = .994$) and between the subject's initial and 24 hour scores ($n = 20$, $r = .976$).

In this study, a 10 cm vertical VAS with a lightly shaded box that enclosed the VAS line and verbal anchors was administered to the subjects (see Appendix D). Each subject's VAS instrument was printed to scale using a Hewlett Packard Laser Jet printer. The investigators administered the vertical VAS to subjects at 2 and 4 hours postoperatively and at 0600 and 1800 each postoperative day for up to 72 hours, or until

the epidural catheter was discontinued. They administered this instrument to subjects using a clipboard, and they gave each subject the same brand fine point pen to mark the scale. Instructions were written in bold enlarged print at the top of the VAS instrument. One of the investigators read the instructions to the subject. The distance from the (0) mark "No pain" to each subject's mark was measured in millimeters with one metal ruler.

Protection of Human Subjects

Permission to conduct this study involving human subjects was obtained from the Institutional Review Board, Dwight David Eisenhower Army Medical Center (DDEAMC), Fort Gordon, Georgia. The investigators obtained written informed consent from all subjects who agreed to participate in the study before receiving any sedative medication (see Appendix E). During the study interview, subjects were informed of the purpose of the study, procedures, risks and benefits, alternative methods of controlling postoperative pain, methods used to report the information from the study, and the possibility of professional journal publication. Informing subjects that information would be reported only as group data, not as individual data, provided assurance of confidentiality. Subjects were informed that they would be given a summary of results upon request. They also were informed that they could refuse to participate or withdraw from the study at anytime without compromising the health care they would receive at the medical center. The subjects were assured that the placement of either a thoracic or lumbar epidural catheter was standard of care and did not alter their anesthetic or surgical plan.

Data Collection

The investigators developed the Epidural Analgesia Study Protocol with assistance from the Anesthesia and Operative Services at DDEAMC (see Appendix F). An abbreviated version of this protocol was given to each anesthesia care provider involved with the subjects' care (see Appendix G). The Epidural Analgesia Study Protocol provided the anesthesia care provider a detailed outline of care to ensure that each subject would receive identical treatment. According to this protocol, one of the investigators would meet with each subject on his day of surgery and obtain written informed consent from each subject who agreed to participate in the study before receiving any sedative medication. After obtaining informed consent, the investigator randomly removed a wooden coin from the study container. This container contained 30 lumbar epidural (L) and 30 thoracic epidural (T) wooden coins. After randomly selecting an epidural coin, the investigator assigned the subject to the group as indicated by the coin. The selected epidural coin was placed into an envelope designated "used coins." In addition, the subject's name was entered in the epidural study log together with the analgesic approach to be implemented. The subject's chart was then identified with an epidural study protocol label. This label alerted the anesthesia care provider to the epidural placement site and analgesics to be delivered.

Prior to induction of general anesthesia, the subjects in the lumbar epidural group received an epidural catheter placed at the L3 - L4 vertebral interspace plus or minus one interspace. After the subject was induced and intubated, a bolus of preservative-free Morphine 30 - 40 mcg/kg was administered through the lumbar epidural catheter. In

addition, a maintenance infusion of preservative-free Morphine was started at 4 -7 cc/hr (40 - 70 mcg /hr) within 30 minutes of the initial bolus intraoperatively. In the event that the epidural needle entered the subarachnoid space upon insertion, the subject was removed from the study and offered alternative postoperative analgesia options.

Prior to induction of a general anesthetic, subjects in the thoracic epidural group received an epidural catheter placed at the T6 - T8 vertebral interspace plus or minus one interspace. After the subject was induced and intubated, a bolus of 0.25% Bupivacaine (.10 - .15 cc/kg) was administered through the thoracic epidural catheter. An infusion of Bupivacaine Hydrochloride 0.25% (.10 - .15 cc/kg/hr) with Fentanyl 5 mcg/cc was delivered to the subject. A maintenance infusion of Bupivacaine Hydrochloride 0.0625% plus Fentanyl 5 mcg/cc at (.10 - .15 cc/kg/hr) was started within 30 minutes of arrival in the SICU or PACU. In the event that the epidural needle entered the subarachnoid space upon insertion, the subject was removed from the study and offered alternative postoperative analgesia options.

Postoperative epidural analgesia orders were generated for each subject that received an epidural (See Appendix H). The epidural study protocol was attached to each subject's Epidural Analgesia Data Tool. In addition, an abbreviated version of this protocol was given to each anesthesia care provider involved with subjects' care. All personnel in the Anesthesia and Operative Service were briefed on the study and protocol guidelines. In addition, all nursing personnel involved in caring for epidural subjects were inserviced on the epidurals and on the study protocol prior to data collection.

The investigators assessed postoperative pain management and administered the VAS to the subjects at 2 and 4 hours postoperatively on the day of surgery and at 0600 and 1800 for a period of 72 hours or until the epidural catheter was discontinued. There was a plus or minus 30 minute window around each data collection point. This window allowed for subjects who were sleeping to be evaluated while awake. There was also a plus or minus 60 minute window for supplemental analgesics given. If a subject received a supplemental analgesic, the investigators returned one hour later for data collection. This accounted for steady state equilibration of the analgesic and allowed for accurate subject reporting of pain level. Epidural Narcotic Analgesia Flowsheet data were assessed and documented by the subject's assigned nurses every hour while the patient had an epidural.

If none of the investigators were available to collect data, the Deputy Director of the Anesthesia Nursing Program assumed data collection responsibilities. To ensure quality control, the Anesthesia and Operative Service was inserviced regarding the study and procedures for implementation prior to data collection. An investigator was assigned on a weekly basis to address any questions from the staff.

Study Design

The design of this study was quasi-experimental (Polit & Hungler, 1995). There was manipulation of the independent variable and random assignment, but there was no control group. Random assignment to either group was accomplished by numbering 60 wooden coins. The 60 coins were divided into two groups of 30. One group was designated as the thoracic epidural group; the coins in this group were marked with a "T."

The other group was designated as the lumbar epidural group; the coins in this group were marked with an "L." All 60 coins were placed in a single container. One coin was selected for each subject at the conclusion of the preanesthetic interview. These coins were not returned to the container. Subject number was recorded and annotated on the Epidural Analgesia Data Tool. This ensured random assignment of the subjects into one of the two groups. Prior to this time, neither the subject nor the investigators were aware of group assignment.

Data Analysis

Data analysis was conducted with consultation from a statistician at the Office of Biostatistics, Medical College of Georgia. The efficacy of the two anesthetic approaches in providing post-thoracotomy analgesia was determined by comparing subjects' post-thoracotomy pain, the number of subjects who requested supplemental analgesics, and the incidence of side effects in the lumbar and thoracic epidural groups. Analgesic requirement after discontinuation of epidural infusion was also analyzed. It was planned that repeated values of subjects' pain scores documented on the VAS would be analyzed with ANOVA for repeated measures. In addition, it was planned that the chi-square goodness-of-fit test would be used to compare differences between the two groups in supplemental analgesia, the incidence of side effects, and analgesic requirement after discontinuation of epidural analgesics. It was planned that findings with a probability of <0.05 would be considered significant.

CHAPTER IV

Analysis of Data

In this chapter, the investigators present data analysis for this study in the following order: sample characteristics and primary findings. All data analyses were performed using SPSS© version 8.0 for Windows.

Sample Characteristics

The convenience sample was drawn from the population of patients who underwent an elective thoracotomy at an Army regional medical center in the southeastern United States and elected to receive an epidural for their post-thoracotomy pain management. A total of 25 patients agreed to participate in the study. Five of the 25 subjects were removed from the study before any post-thoracotomy data could be collected. Of these five subjects, one developed unstable atrial fibrillation after consent; one received an epidural that was not working intra-operatively and was removed upon completion of surgery; one received benzodiazepine before being able to sign the consent; one remained on a ventilator postoperatively and was unable to complete the VAS; and one had a migration of the epidural catheter into the subarachnoid space.

Therefore, the total sample size for the study was 20 subjects. Ten of these subjects were randomly assigned to the thoracic group, and ten were randomly assigned to the lumbar group. Sample characteristics are presented in Table 1. The percentage of subjects 50 to 79 years of age was higher in the lumbar epidural group (70%) than in the thoracic epidural group (50%). Both the lumbar and thoracic epidural groups consisted of predominately male subjects. In addition, a lung resection was performed on 90% of

Table 1

Sample Characteristics for the Thoracic and Lumbar Epidural Groups

Characteristic	Epidural Group	
	Thoracic (n = 10)	Lumbar (n = 10)
Age		
20 – 34	3	0
35 – 49	2	3
50 – 64	3	4
65 – 79	2	3
Gender		
Male	9	7
Female	1	3
ASA		
I	2	0
II	4	8
III	4	2
Procedure		
Lung Resection	5	9
Thoracoplasty	1	1
Rib Resection	1	0
VATS	3	0

Note. Age = Age in years. ASA = American Society of Anesthesiologists Classification. VATS = Video Assisted Thoracic Surgery.

the subjects in the lumbar group and 50% of the subjects in the thoracic group. Video assisted thoracic surgery (VATS) was performed on 30% of the subjects in the thoracic group but on none of the subjects in the lumbar group.

Of the 20 subjects, 8 completed all the data collection points on the day of surgery and the three postoperative days (see Table 2). Five of these subjects were in the thoracic group, and three were in the lumbar group. Twelve subjects did not complete all of the data collection points for the following reasons: three had dislodged epidural catheters, two had epidural catheters that were discontinued for neurological evaluation, two had epidural catheters that were discontinued for discharge home, and five had epidural catheters that were discontinued due to inadequate pain control (see Table 3). All subjects who were unable to complete the study were offered supplemental analgesics as prescribed by the Anesthesia and Operative Service at the study site.

Primary Findings

The purpose of this study was to evaluate the analgesic efficacy of a continuous infusion of preservative-free Morphine via the lumbar epidural approach as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients. It had been planned that a repeated measures analysis of variance (ANOVA) would be used to analyze the differences between the mean VAS scores of the two epidural groups. However, this analysis was not possible because of the large range of variability in the individual VAS scores, the small sample size, and the fact that the sample was not normally distributed. Therefore, a series of one-way ANOVAs was done to compare the mean

Table 2

Number of Subjects at Each Data Collection Point for the Thoracic and Lumbar Epidural Groups

	Day of Surgery		POD 1		POD 2		POD 3	
Group	2 hrs	4 hrs	0600	1800	0600	1800	0600	1800
Thoracic	10	10	10	9	9	7	7	5
Lumbar	10	10	9	8	7	6	5	3

Note. Group = Thoracic or lumbar epidural group. Day of Surgery = 2 and 4 hours after surgery. POD = 0600 and 1800 hours on the first, second, and third postoperative days.

Table 3

Cause of Subject Attrition for the Thoracic and Lumbar Epidural Groups

	Epidural Group	
Cause of Attrition	Thoracic	Lumbar
Epidural Catheter Dislodged	1	2
Inadequate Pain Control	3	2
Neurological Evaluation	0	2
Discharged to Home	1	1
Total	5	7

VAS scores of the thoracic and lumbar groups at each data collection point (Glantz, 1997). In addition, it had been planned that the chi-square test would be used to analyze the differences between the two groups' request for supplemental analgesics, side effects, and time to first analgesic after discontinuation of epidural analgesia. However, because of the small sample size and the fact that the expected frequency for a group was less than five in some of the cells of the two way tables, the Fisher exact test was used for these analyses (Glantz, 1997). The probability value for statistically significant findings was set at $p < 0.05$.

Power analysis initially was calculated for a medium effect size. However with the sample obtained, the power was .40. Power analysis indicated that a sample of 128 subjects (64 in each group) would be sufficient for a medium effect size and should be considered for future research.

Hypothesis 1: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will report no difference in post-thoracotomy pain while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

Summary statistics for the VAS scores are presented in Table 4. As noted in the table, the difference between the mean VAS scores in the lumbar and thoracic groups ranged from .01 to 14.80 mm at seven of the eight data collection times. However, at 1800 hours on postoperative day (POD) 2, the mean VAS score for the lumbar group was

Table 4

Summary Statistics of Visual Analog Scale (VAS) Scores at Each Data Collection Point for the Thoracic and Lumbar Epidural Groups

	Day of Surgery		POD 1		POD 2		POD 3	
Summary Statistic	2 hrs	4 hrs	0600	1800	0600	1800	0600	1800
				Thoracic Epidural Group				
M	31.70	35.90	30.10	26.44	24.56	18.14	17.29	8.20
SEM	9.28	9.42	9.22	8.36	9.59	13.10	10.68	5.84
Mdn	33.50	35.00	23.50	12.00	11.00	5.00	4.00	3.00
Range	0 – 81	1 – 94	4 – 100	3 – 61	1 – 78	0 – 96	0 – 79	0 – 31
n	10	10	10	10	9	7	7	5
				Lumbar Epidural Group				
M	34.90	22.80	30.11	19.63	30.57	53.00	22.20	23.00
SEM	9.21	6.58	9.64	7.13	9.09	10.33	7.68	10.44
Mdn	29.00	19.50	29.00	9.50	34.00	46.50	24.00	21.00
Range	0 – 75	0 – 60	0 – 88	0 – 49	5 – 69	29 – 82	10 – 40	6 – 42
n	10	10	9	8	7	6	5	3

Note. POD = Postoperative day. M = Mean VAS score. SEM = Standard error of the mean. Mdn = Median VAS score. Range = Range of VAS scores in millimeters on a 100 mm scale. n = Sample size at each data collection point.

53.00 mm (range = 29 – 82 mm), while the mean VAS score for the thoracic group was 18.14 mm (range = 0 – 96 mm) (see Figure 2). This represents a difference of 34.86 mm between the mean VAS scores of the two groups for this time point. In addition, there was a large degree of variability in the individual VAS scores. The range of VAS scores for the thoracic group was 0 – 100 mm, while the range of VAS scores for the lumbar group was 0 - 88 mm.

A one-way ANOVA was done for each data collection point through the first postoperative day (POD) to compare the mean VAS scores of the two groups. There were at least 17 subjects at each of the four data collection points through POD 1, but there was an increased attrition rate on the second and third postoperative days. No statistically significant differences in the mean VAS scores were found at the two time points on the DOS or at 0600 or 1800 on POD 1: (F (1, 18) = .06, p = .81; F (1, 18) = 1.30, p = .27; F (1, 17) = 1.00, p = 1.00; F (1, 15) = .38, p = .55). These findings support acceptance of hypothesis 1.

Hypothesis 2: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in the requirement for supplemental analgesia while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

The number and percentage of subjects who required supplemental analgesics in the thoracic and lumbar epidural groups at each data collection point are presented in Table 5. Less than 40% of subjects in the thoracic group required supplemental analgesics at all

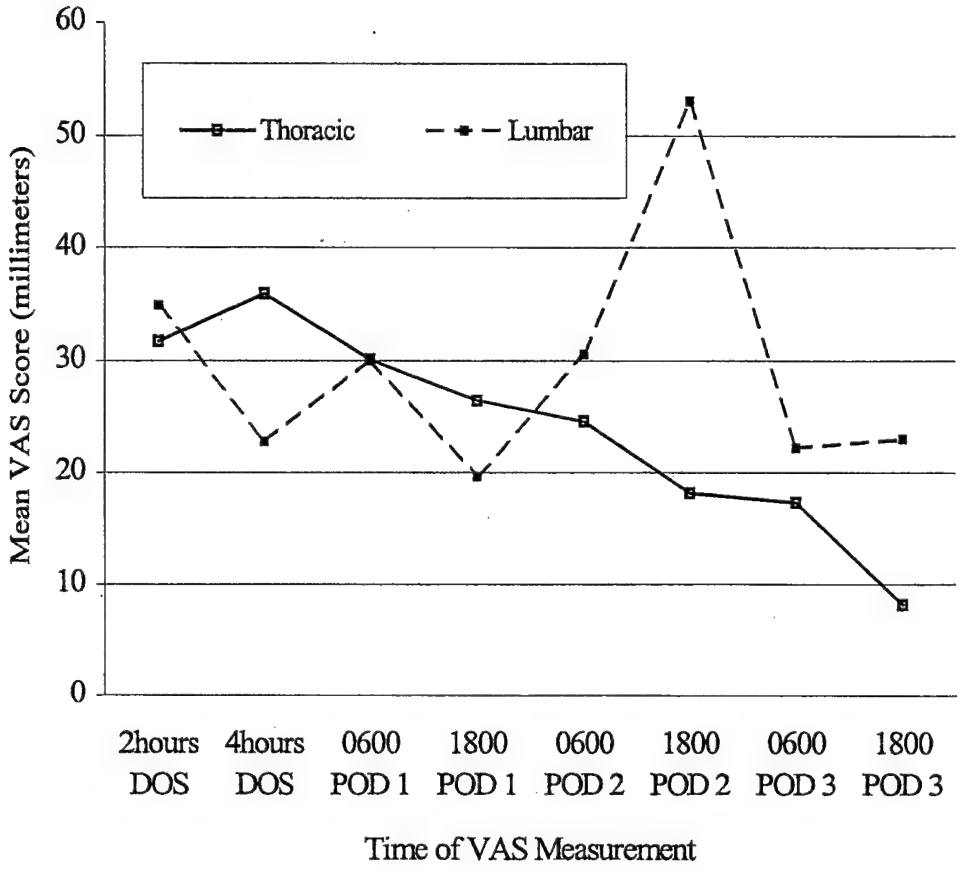


Figure 2.

Mean Visual Analog Scale (VAS) scores for the thoracic and lumbar epidural groups from 2 hours postoperatively on the day of surgery (DOS) through 1800 on postoperative day (POD) 3.

data points with the exception of 43% at 0600 on POD 3. Less than 40% of subjects in the lumbar group required supplemental analgesics at all data points with the exception of 50% at 2 hours after surgery, 43 % at 0600 on POD 2, and 50% at 1800 on POD 2.

The Fisher exact test was used to compare the number of subjects in each group who required supplemental analgesics at each data collection point. No statistically significant difference existed between the number of subjects who required supplemental analgesics in the two groups at any of the data collection points (see Table 5). These findings support acceptance of hypothesis 2.

Hypothesis 3: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic side effects while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride and Fentanyl.

The number and percentage of subjects with side effects in the thoracic and lumbar epidural groups are presented in Table 6. Only three side effects were reported: nausea or vomiting, pruritis, and respiratory depression. All side effects were quickly alleviated with appropriate intervention. In addition, no subject had more than one side effect. As noted, the percentage of subjects who experienced any side effect in the thoracic group was 60% ($n = 6$). The percentage of subjects who experienced any side effect in the lumbar group was 30% ($n = 3$).

The Fisher exact test was done to compare the number of subjects in each group who experienced side effects. Data were collected and analyzed for all data collection points.

Table 5

Number and Percent of Subjects Who Required Supplemental Analgesics in the Thoracic and Lumbar Epidural Groups at Each Data Collection Point

	Day of Surgery		POD 1		POD 2		POD 3	
Group	2 hrs	4 hrs	0600	1800	0600	1800	0600	1800
	(p = .65)	(p = .58)	(p = .59)	(p = .63)	(p =1.00)	(p = .22)	(p = 1.00)	(p = 1.00)
Thoracic	3 (30%)	3 (30%)	3 (30%)	2 (22%)	3 (33%)	1 (14%)	3 (43%)	1 (20%)
Lumbar	5 (50%)	1 (10%)	2 (22%)	3 (38%)	3 (43%)	3 (50%)	1 (20%)	0 (0%)

Note. Numbers outside parentheses represent number of subjects who received supplemental analgesics at each data collection point. Numbers inside parentheses represent the percentage of subjects who required supplemental analgesics at each data collection point. p = Probability value with the Fisher exact test.

Table 6

Number and Percent of Subjects With Side Effects in the Thoracic and Lumbar Epidural Groups

Group	Hypotension (p = 1.00)	Postoperative N/V (p = .21)	Pruritis (p = 1.00)	Respiratory Depression (p = 1.00)	All Side Effects (p = .37)
Thoracic	0 (0%)	3 (30%)	3 (30%)	0 (0%)	6 (60%)
Lumbar	0 (0%)	0 (0%)	2 (20%)	1 (10%)	3 (30%)
Total	0	3	5	1	9

Note. N/V = Nausea and or vomiting. p = Probability value obtained with Fisher exact test.

No statistically significant difference was found between the total number of subjects with side effects in the thoracic and lumbar groups ($p = .37$) (see Table 6). These findings support acceptance of hypothesis 3.

Hypothesis 4: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic requirement after discontinuation of the epidural analgesics than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

The requirement for first analgesic after discontinuation of epidural analgesia for the thoracic group ranged from 0 to 11 hours (660 minutes) ($M = 147.10$ minutes, SEM = 63.95 minutes). The requirement for first analgesic after discontinuation of epidural analgesia for the lumbar group ranged from 0 to 12 hours (720 minutes) ($M = 159.50$ minutes, SEM = 82.08 minutes). The Fisher exact test was used to compare the mean time to first analgesic after discontinuation of epidural analgesics of the two groups. Data were collected and analyzed on all 20 subjects, regardless of how many of the eight proposed data collection points they completed. No statistically significant difference was found when the mean times to first analgesic requirement of the two groups were compared ($p = 1.00$). These findings support acceptance of hypothesis 4.

CHAPTER V

Discussion, Conclusions, Implications, and Recommendations

The effectiveness of epidurals in providing post-thoracotomy analgesia is well documented in the literature. Reports and studies to date have compared the lumbar and thoracic epidural approaches using the same analgesic for each approach. No study was found that compared the lumbar and thoracic epidural approaches using analgesics tailored to each site based upon their pharmacokinetic profiles. The purpose of this study was to evaluate the analgesic efficacy of a continuous infusion of preservative-free Morphine via the lumbar epidural approach as compared to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients. In this chapter, the investigators interpret findings as they relate to the cited research and the conceptual framework, discuss study limitations, draw conclusions from the study findings, discuss implications for the practice of nursing anesthesia, and discuss recommendations for further research.

Discussion

This study is the first to compare a continuous infusion of preservative-free Morphine via the lumbar epidural approach to a continuous infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl via the thoracic epidural approach in post-thoracotomy patients. Published reports to date have compared the same analgesic using two different approaches or different analgesics using the same approach. No studies have compared the thoracic and lumbar approaches using site appropriate analgesics based on their pharmacokinetic profiles.

The investigators found no statistically significant differences between the two groups' VAS scores, number of supplemental analgesics, incidence of side effects, or the time to first analgesic requirement after epidural analgesics were discontinued. However, the small sample size and the resulting low power that was obtained in the study (power = .40) make it more likely that there was not enough power in the statistical test to detect differences, even though they may have existed. Therefore, no generalizations can be made regarding the fact that no statistically significant differences were found in any of the data analyses. However, descriptive statistics regarding the adequacy of post-thoracotomy analgesia provided by the two approaches and findings that are supported by previous studies provide a basis for continued research regarding the thoracic and lumbar epidural approaches to post-thoracotomy analgesia.

Hypothesis 1: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will report no difference in post-thoracotomy pain while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

The investigators found no statistically significant differences in the mean VAS scores between the thoracic and lumbar epidural groups at any of the data collection points. It should be noted that no difference was found in the VAS scores of these two groups in spite of the differences in the types of procedures performed in the two groups. In the thoracic group, video assisted thoracic surgery (VATS) was performed on 3 of the 10 subjects. However, no subjects in the lumbar group had a VATS procedure. The

surgical and postoperative stimulus with a VATS procedure is considerably less than what is experienced with a lung resection. Therefore, it would be expected that more subjects in the thoracic group would have had less pain than subjects in the lumbar group and that their pain would have been easier to manage with epidural analgesics.

A large range of individual VAS scores existed in both the thoracic (0 – 100 mm) and lumbar (0 – 88 mm) epidural groups. However, the mean VAS score was less than 40 mm in both groups at all data collection points with the exception of a mean VAS score of 53.00 mm for the lumbar group at 1800 on postoperative day (POD) 2. Coe et al. (1991), Guinard et al. (1992), and Sawchuck et al. (1993) reported that their mean VAS scores were less than 40 mm when comparing the same analgesics (Bupivacaine, Fentanyl, or Morphine) with the thoracic and or lumbar approaches for post-thoracotomy pain management. These researchers interpreted a mean VAS score of less than 40 mm on a 100 mm scale as indicating adequate analgesia. Using this standard, it can be said that, on the average, in this study adequate analgesia was reported by subjects in both epidural groups at all data collection points with the exception of the lumbar group at 1800 on POD 2.

Hypothesis 2: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in the requirement for supplemental analgesia while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

The investigators found no statistically significant difference in the number of subjects who required supplemental analgesics between the two epidural groups. No statistically significant difference existed at any data collection point between the thoracic and lumbar groups when interpreting the number and percentage of subjects who received supplemental analgesics in each group. It should be noted that the requirement for supplemental analgesics may have been increased because of nonfunctioning catheters in some subjects. This is suspected because three subjects were known to have had dislodged epidural catheters (see Table 3). Five other subjects who had inadequate pain control may have had poorly functioning epidural catheters. In addition, it was common practice at the time of the study for nurses at the study site to treat all post-thoracotomy patients with supplemental analgesics prior to ambulating or doing breathing exercises regardless of whether patients were complaining of pain. For these reasons, the number of supplemental analgesics given to the subjects may be greater than the number of supplemental analgesics actually required by the subjects for adequate post-thoracotomy pain management.

The findings about supplemental analgesics are unique to this study because the investigators are the first to compare epidural approaches with site appropriate analgesics. In similar studies, only increases in the epidural infusion rate or number of epidural boluses were reported; no other routes (oral or parenteral) of supplemental analgesics were included in the data analyses in these other studies (Coe et al., 1991; Guinard et al., 1992; Sawchuck et al., 1993).

Hypothesis 3: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic side effects while the epidural infusion is being administered than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride and Fentanyl.

The investigators found no statistically significant difference in the overall incidence of side effects between the two epidural groups. In this study, 60% ($n = 6$) of the subjects in the thoracic group and 30% ($n = 3$) of the subjects in the lumbar group experienced side effects. Stenseth, Sellevoid and Brevik (1985) reported that an overall incidence of side effects of 30% was considered acceptable for intravenous analgesic administration. Furthermore, these investigators reported that an overall incidence of side effects less than 30% was needed for the risk-benefit ratio of epidural administered analgesics to be acceptable.

Thirty percent of the subjects ($n = 3$) in the lumbar group had side effects (2 with pruritis and 1 with respiratory depression). The subjects who had pruritis were treated with diphenhydramine and continued to receive the lumbar epidural infusion for postoperative pain management. The subject who developed respiratory depression was found to have an elevated level of carbon dioxide on his arterial blood gas, but he did not exhibit signs and symptoms of respiratory depression. The epidural infusion rate was decreased from 7 cc/hr to 5 cc/hr. The epidural rate was later increased to 7 cc/hr when subsequent arterial blood gases were found to be within normal limits and after the subject complained of pain. It is not known if the alteration in the subject's arterial blood

gas was related to his disease process or was a side effect of the epidural analgesia.

Sixty percent ($\underline{n} = 6$) of the subjects in the thoracic group had side effects (3 with nausea or vomiting and 3 with pruritis). The three subjects who had nausea or vomiting were treated with metoclopramide. The three subjects who had pruritis were treated with naloxone and diphenhydramine. One subject who was treated with naloxone experienced pain after receiving an accidental high dose of naloxone by the ward nurse. At subsequent data collection points, the subject reported adequate pain relief with no further incidence of pruritis. Similar findings were reported by Fromme et al. (1991). They found that respiratory depression accounted for less than 2% of the side effects in the thoracic and lumbar groups when the same analgesics were used for each group. They did not report any other side effects.

It should be noted that some of the side effects reported may have been related to intraoperative analgesics, supplemental analgesics, or other medications such as antibiotics. If this is true, the actual incidence of side effects related to the epidural analgesics would be less than 60% for the thoracic and less than 30% for the lumbar group. Therefore, it is recommended that a protocol be implemented for future studies to control for the intraoperative medications and define side effects in a more precise manner.

The side effects reported in this study are in contrast to the findings of Saito et al. (1994), who compared continuous thoracic epidural infusions of preservative-free Morphine plus Bupivacaine to Fentanyl plus Bupivacaine and studied the associated incidence of side effects of each. Systolic arterial blood pressure below 90 mmHg was

found to occur in 73% of the preservative-free Morphine group (PFMG) compared to 45% of the Fentanyl group. Pruritus occurred in 80% of the PFMG compared to 25% of the Fentanyl group. Nausea and vomiting occurred in 20% of the PFMG compared to 15% in the Fentanyl group, while extremity numbness occurred in 8% of the PFMG compared to 5% in the Fentanyl group. None of the 95 subjects studied developed respiratory depression. Urinary retention was not evaluated because all patients received an indwelling urinary catheter.

Saito et al. (1994) concluded that in the thoracic approach, patients receiving preservative-free Morphine plus Bupivacaine experienced a greater incidence of these side effects when compared to those receiving Fentanyl plus Bupivacaine. It should be noted that Saito et al. (1994) found an increased incidence of side effects in the PFMG when Morphine was being used with the thoracic approach. Morphine with the thoracic approach does not exhibit the segmental spread that Fentanyl and Bupivacaine exhibit with the thoracic approach. Therefore, based upon the pharmacokinetic properties of Morphine, the rostral spread of this analgesic may promote the increased incidence of side effects when administered with the thoracic approach.

Hypothesis 4: Post-thoracotomy patients who receive a continuous lumbar epidural infusion of preservative-free Morphine will have no difference in analgesic requirement after discontinuation of the epidural analgesics than will post-thoracotomy patients who receive a continuous thoracic epidural infusion of 0.0625% Bupivacaine Hydrochloride plus Fentanyl.

The investigators found no statistically significant difference between the two groups in the time to first analgesic required after discontinuation of epidural analgesics. The investigators used analgesics that were site appropriate for both the thoracic and lumbar epidural approaches based on their pharmacokinetic profiles. Clinically, this finding was surprising based on the fact that preservative-free Morphine exhibits a longer duration of action in the epidural space than does Bupivacaine plus Fentanyl.

However, at the data collection site it was common practice at the time of the study for nurses to treat all post-thoracotomy patients with analgesics immediately after the epidural catheter was discontinued. Because of this practice, it is likely that at least some subjects received supplemental analgesics after the epidural catheter was discontinued prophylactically rather than based on actual complaint of pain. In addition, the exact time when the epidural catheter was dislodged from the epidural space is not known. It is possible that some subjects were not receiving epidural analgesics for a considerable period of time before their catheter was discontinued because of a poorly functioning or partially dislodged catheter. Therefore, for these reasons, the reported time to first analgesic after discontinuation of epidural analgesics may not be an accurate reflection of the amount of time between discontinuation of epidural analgesics and onset of pain.

In summary, it should be emphasized that there were subjects in both the thoracic and lumbar groups who had very good postoperative pain management. Six subjects (four in the thoracic and two in the lumbar group) did not require any epidural rate increases or supplemental analgesics at any of the eight data collection points through their entire postoperative course. The four subjects in the thoracic group had a mean

VAS score of 9.00 mm. These four subjects had two different thoracic procedures (two subjects had a lung resection and two subjects had a VATS). The subjects in the lumbar group had a mean VAS score of 9.5 mm. These two subjects each had a lung resection.

At the same time, some subjects in the study had less than optimal postoperative pain management as evidenced by mean VAS scores greater than 40 mm and their need for supplemental analgesics at several data collection points. Two subjects, one in the thoracic and one in the lumbar group, required an epidural rate increase and supplemental analgesics at each of the four data collection points through POD 1. The subject in the thoracic group had VAS scores of 94 mm at 2 hrs after surgery, 48 mm at 4 hrs after surgery, 50 mm at 0600 on POD 1, and 61 mm at 1800 on POD 1. The subject in the lumbar group had VAS scores of 50mm at 2 hrs after surgery, 48 mm at 4 hrs after surgery, 29 mm at 0600 on POD 1, and 55 mm at 1800 on POD 1. Both of these subjects had a lung resection. It is interesting to note that these two subjects completed all eight data collection points but did not receive any further rate increases for the remainder of the study. However, their mean VAS scores for the remainder of the data collection points were greater than 40 mm (lumbar group mean VAS score = 61 mm; thoracic group mean VAS score = 50 mm).

Conceptual Framework

Roy's adaptation model describes the person as an adaptive system that responds to situations based on his current level of adaptation. Input is defined as either internal or external stimuli to the system. Throughput is defined as coping mechanisms and effectors or adaptive modes, which are used to adapt to a stimulus. Output is defined as

adaptive responses when coping mechanisms and effectors respond appropriately to a given stimulus. Inappropriate responses occur when the system is unable to adapt effectively or lacks baseline internal stimuli (Roy & Andrews, 1991).

Injections of an opioid or an opioid plus a local anesthetic into the epidural space block sensory transmission and modulate pain perception. This input helps the person adapt to the stresses involved with surgery. The expected effect of a continuous administration of epidural medication is to augment a person's ability to adapt to the pain associated with a thoracotomy. Overall, both epidural approaches facilitated an adaptive response. This result supports the use of epidural analgesics in controlling post-thoracotomy pain. This adaptation to the stress of a thoracotomy helped the investigators conclude that Roy's adaptation model was useful in developing the conceptual framework for this study.

Statistical testing of the hypotheses indicated that no statistically significant differences existed between the two groups in their mean VAS scores, number of supplemental analgesics, side effects, or the requirement for analgesics after discontinuation of epidural analgesia. The investigators found evidence of adaptive function in subjects whose post-thoracotomy pain was adequately managed using both the thoracic and lumbar epidural approaches. Viewed in terms of Roy's model, these results represent the subjects' adaptive responses to surgery facilitated by the injection of medication into the epidural space to modulate their pain responses. The results of the entire hypothesis testing support the investigators' conceptual framework based on Roy's adaptation model.

Limitations

Several limitations should be considered when interpreting the findings. The investigators utilized a convenience sample with random assignment to each epidural group. It is not known if the sample is characteristic of all patients who receive a thoracic or lumbar epidural for post-thoracotomy analgesia. This study is also limited by the large attrition rate of the sample over time. The number of subjects who completed all the data collection points was 38% (8 out of 20 subjects). This represents a 62% attrition rate. Therefore, the results of this study are not generalizable outside the study sample.

Finally, the study was limited by the small sample size and power obtained. The investigators planned to continue data collection until a sample of 30 subjects was obtained in each of the two groups. However, data collection stopped with a sample size of 20 subjects due to the lack of scheduled procedures at the data collection site and time constraints of the investigators. This sample size had a power of .40. This means that the chance for a type II error existed. A type II error exists when there is not enough power in the statistical test to detect differences when one actually exists. (Glantz, 1977).

Conclusions

The investigators cannot make any conclusions regarding a comparison of the efficacy of post-thoracotomy analgesia provided by the lumbar and thoracic epidural approaches because of the limitations of this study. However, the investigators demonstrated that it is possible to provide effective post-thoracotomy pain management using site appropriate analgesics with both the lumbar and thoracic epidural approaches. Therefore, based on these findings, the anesthesia care provider should consider both

approaches as viable options when using site appropriate analgesics for post-thoracotomy pain management.

Second, the investigators demonstrated that continuing education needs to be an integral part of successful epidural analgesia administration. As noted, there were some subjects who had VAS scores greater than 40 mm at some of the data collection points but did not receive supplemental analgesics. Other subjects received supplemental analgesics even though they had very low VAS scores. In addition, three subjects were known to have inadvertently dislodged epidural catheters; it is not known if any preventive measures were taken to ensure that these epidural catheters were properly secured and maintained. Continuing education is needed to reinforce the understanding of epidurally administered analgesics for both the anesthesia care provider and other health care professionals who provide care to post-thoracotomy patients.

Implications for Nursing Anesthesia Practice

The investigators cannot make practice recommendations concerning the use of one epidural analgesic approach over the other because of the limitations of this study. However, in this study, the investigators demonstrated that it is possible to provide effective post-thoracotomy pain management using both the lumbar and thoracic approaches. Therefore, the safer and technically easier lumbar epidural approach should be considered when selecting an epidural approach for the thoracotomy patient in certain cases. For example, the lumbar epidural approach should be considered in instances in which the anesthesia care provider is not proficient in the thoracic epidural approach or when this approach is more difficult because of specific patient characteristics.

Recommendations

The investigators are the first to compare the thoracic and lumbar epidural approaches to post-thoracotomy pain management using site appropriate analgesics based on their pharmacokinetic profiles. Findings of this study indicate that subjects received effective post-thoracotomy pain management with both approaches. However, the findings do not support or refute the use of one epidural approach over the other because of the small sample size.

Therefore, it is recommended that a larger controlled study be conducted to compare the efficacy of post-thoracotomy pain management provided by the lumbar approach using preservative-free Morphine and the thoracic approach using Bupivacaine plus Fentanyl. This future study should employ random selection at multiple study sites; this would allow for a larger sample size to be obtained. In addition, the investigators of this future study should institute a protocol for the intraoperative doses of all analgesics used. It is also suggested that an epidural catheter protocol be used to ensure that the epidural catheter is secured postoperatively. This should help decrease the attrition rate and increase the number of data collection points completed by the subjects. Furthermore, it is suggested that the number of data collection points be increased in this future study. This may help the investigators determine when the epidural catheter becomes dislodged and should provide a more accurate reflection of the time to first analgesic after epidural analgesics are discontinued. Finally, relationships among age, gender, type of thoracotomy procedure, and individual anesthesia care provider approaches for epidural catheter placement should be explored in this future study.

APPENDIX A

Epidural Analgesia Data Tool

Demographic data			
Study Participant # : T-_____ or L-_____	Start of Surgery: End of Surgery:	Allergies:	ASA classification: I II III IV
Age:___ Phone #: _____	Sex:_____	Height:_____ft _____in	Weight:____lbs ____kgs
Thoracotomy Procedure: _____.		Epidural Placement Complications:_____.	

Epidural Infusional Log			
Anesthesia Start Time _____ Anesthesia End Time_____ Volume delivered in the OR_____ cc.		Total Volume of epidural infusate delivered via the epidural catheter when D/C'd: Amount_____ cc's.	
Check applicable box below: ☐ Fentanyl & Bupivicaine ☐ PF Morphine Number of Puncture Attempts: _____		Epidural Placement Level T-_____ or L-_____	Epidural analgesics D/C'd Date_____ Time_____
DOS 2 hrs postop	1st POD 0600	2nd POD 0600	3rd POD 0600
Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)
# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.
Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus
DOS 4 hrs postop	1st POD 1800	2nd POD 1800	3rd POD 1800
Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)	Epidural Rate:_____cc/hr Rate Change: Inc or Dec By ____cc/hr. (circle)
# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.	# of Supplemental Analgesics since last assessment _____.
Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus	Side Effects: (if apply) _ Hypotension _ Resp.Depression _ PONV _ Pruritus

Comments

SUPPLEMENTAL ANALGESIC RECORD					
Date	Time	POD #	Drug	Dose	Route
					_IV _Epid _IM _po
					_IV _Epid _IM _po
					_IV _Epid _IM _po
					_IV _Epid _IM _po
					_IV _Epid _IM _po
					_IV _Epid _IM _po
					_IV _Epid _IM _po

APPENDIX B

Epidural Narcotic Analgesia Flowsheet (DA 4700)

REPORT TITLE

Epidural Narcotic Analgesia Flowsheet

OTSG APPROVED (Date)

Level of Insertion: _____

Mx/Conc: _____ Date:

TIME*	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	01	02	03	04	05
RATE																								
BOLUS: SPECIFY IV/EPI ROUTE																								
TOTAL VOLUME DELIVERED																								
SEDATION LEVEL**																								
ANALGESIA LEVEL***																								
RESPIRATION RATE																								
SIDE EFFECTS****																								
NURSE INITIALS																								

*DOCUMENTATION:
Must be done on the flowsheet at least every ___ hours.
Resp rate q 1 hour x ___ hours.

**SEDATION LEVEL SCALE
1. Wide Awake
2. Drowsy
3. Dozing Intermittently
4. Mostly sleeping
5. Awakens only when aroused

***ANALGESIA LEVEL SCALE
1. Comfortable
2. Mild Discomfort
3. Pain
4. Bad Pain
5. Very Bad Pain

****SIDE EFFECTS
P = Pruritus
U = Urinary Retention
M = Motor Block
N = Nausea

NURSE INITIAL/SIGNATURE	COMMENTS:

(Continue on reverse)

PREPARED BY (Signature & Title) | DEPARTMENT/SERVICE/CLINIC | DATE

PATIENT'S IDENTIFICATION (For typed or written entries give: Name—last, first, middle; grade; date; hospital or medical facility)

☐ HISTORY/PHYSICAL ☐ FLOW CHART
☐ OTHER EXAMINATION OR EVALUATION ☐ OTHER (Specify)
☐ DIAGNOSTIC STUDIES
☐ TREATMENT

DA FORM 1 MAY 76 4700

*U.S. GPO: 1993-300-727/80365

EAMc OP 552, 1 Oct 95

APPENDIX C

Medication Administration Record

CLINICAL RECORD — THE[illegible]PEUTIC DOCUMENTATION CARE PLAN ([illegible]DICATIONS)

For use of this form, see AR 40-407; the proponent agency is the Office of The Surgeon General.

Mo. Yr.

VERIFY BY INITIALING

INITIAL PROPER COLUMN FOLLOWING EACH ADMINISTRATION

ORDER DATE	CLERK/ NURSE	RECURRING MEDICATIONS, DOSE, FREQUENCY	HR	DATE DISPENSED

ALLERGIES: ☐ YES ☐ NO

PRIMARY DIAGNOSIS:

ADDITIONAL PAGES IN U ☐ YES ☐ NO

PAGE NO.

PATIENT IDENTIFICATION:

DISPENSING TIMES

USE PENCIL, CIRCLE MED TIMES

D 7 8 9 10 11 12 13 14

E 15 16 17 18 19 20 21 22

N 23 24 01 02 03 04 05 06

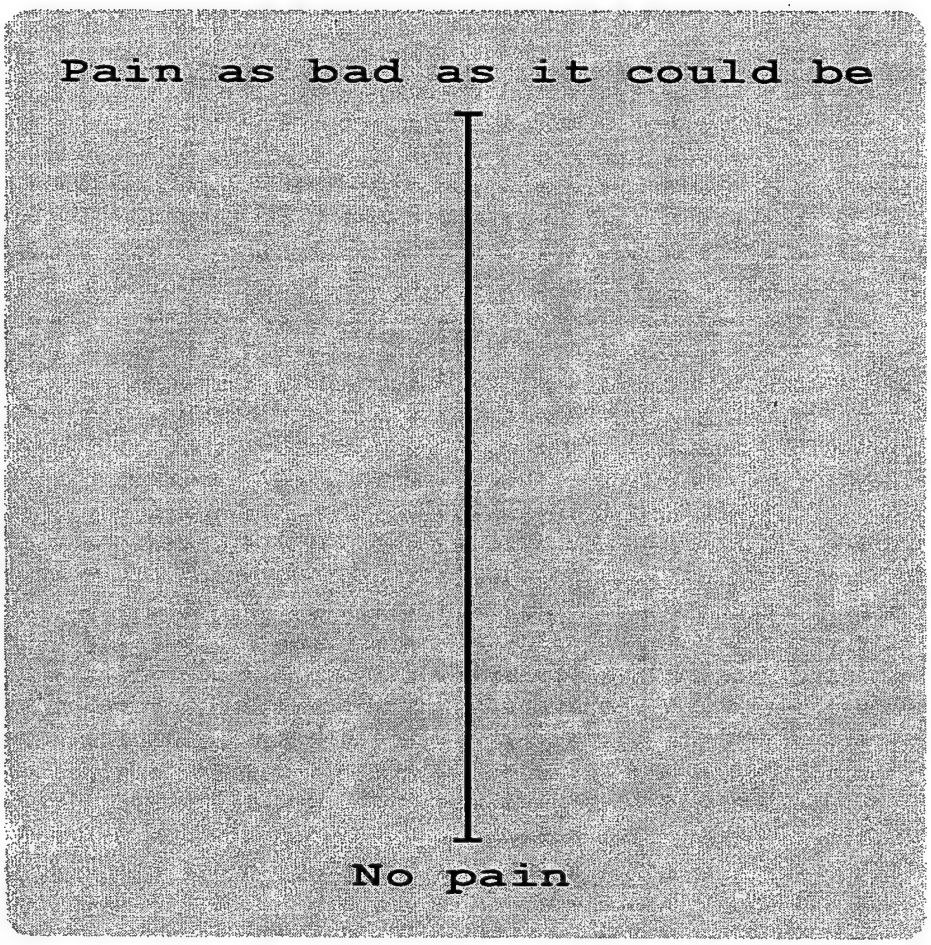
DA FORM 1 FEB 79 4678

EDITION OF 1 DEC 77 WILL BE USED UNTIL EXHAUSTED.

APPENDIX D

Visual Analog Scale

Instructions: Estimate the level of pain you are having at this moment. Imagine the line below is a thermometer. At the top of the thermometer is "Pain as bad as it could be" and at the bottom of the thermometer is "No pain". Draw a single straight line across the thermometer, at the level that best represents your pain now.



APPENDIX E

Epidural Study Consent

VOLUNTEER AGREEMENT AFFIDAVIT

For use of this form, see AR 70-25; the proponent agency is OTSG

PRIVACY ACT OF 1974

Authority: 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Principle Purpose: To document voluntary participation in the Clinical Investigation and Research Program. SSN and home address will be used for identification and locating purposes.

Routine Uses: The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study, implementation of medical programs, adjudication of claims and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State and local agencies.

Disclosure: The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in the investigational study.

PART A(1) - VOLUNTEER AFFIDAVIT

Volunteer Subjects in Approved Department of the Army Research Studies

Volunteers under the provisions of AR 40-38 and AR 70-25 are authorized all necessary medical care for injury or disease which is the proximate result of their participation in such studies.

I,_____, SSN_____,
having full capacity to consent and having attained my _____ birthday, do hereby volunteer/give consent as legal representative for _____ to participate in _____
A comparison of the effectiveness of a continuous lumbar epidural infusion of preservative free Morphine with a continuous thoracic epidural infusion of 0.0625% Bupivacaine plus Fentanyl in providing post thoracotomy analgesia.

(Research Study)

under the direction of CPT James Williams, AN and/or members of the Anesthesia & Operative Service.

conducted at Eisenhower Army Medical Center

(Name of Institution)

The indications of my voluntary participation/consent as legal representative; duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by:

CPT James Williams or associate

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights/the rights of the person I represent on study-related injury, I may contact:

Center Judge Advocate (706)787-4097 or the Clinical Research Protocol Coordinators

at Eisenhower Army Medical Center, Ft. Gordon, Ga (706)(787-4273)

(Name, Address and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my consent and withdraw/have the person I represent withdrawn from the study without further penalty or loss of benefits; however, the person I represent may be required (military volunteer) or requested (civilian volunteer) to undergo certain examinations if, in the opinion of the attending physician, such examinations are necessary for my/the person I represent's health and well-being. My/the person I represent's refusal to participate will involve no penalty or loss of benefits to which I am/the person I represent is otherwise entitled.

PART A(2) - ASSENT VOLUNTEER AFFIDAVIT (MINOR CHILD)

I,_____, SSN_____,
having full capacity to consent and having attained my _____ birthday, do hereby volunteer for _____ to participate in _____

(Research Study)

under the direction of _____
conducted at _____

(Name of Institution)

(Continue on Reverse)

PART A(2) - ASSENT VOLUNTEER AFFIDAVIT (MINOR CHILD) (Cont'd)

The implications of my voluntary participation; the nature, duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconvenience and hazards that may reasonably be expected have been explained to me by

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights I may contact

at_____

(Name, Address and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my assent and withdraw from the study without further penalty or loss of benefits; however, I may be requested to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my health and well-being. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

PART B - TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: (Provide a detailed explanation in accordance with Appendix E, AR 40-38 or AR 70-25).

Because you have chosen the epidural method of pain control for your surgery, you are invited to participate in this study. There are generally two places on your back where this epidural may be placed, either in your lower (lumbar) or middle (thoracic) back. You will receive specific medications for the site that the epidural is placed. The purpose of this study is to determine if the lumbar epidural route, providing a dose of preservative free Morphine (a narcotic) is capable of providing equivalent pain relief to a post-thoracotomy (surgery to the chest) patient as Fentanyl (a narcotic) and Bupivacaine (a local anesthetic) administered via the thoracic route. A lumbar placed epidural with preservative free Morphine or a thoracic placed epidural with Fentanyl and Bupivacaine will be used in this study. All of these agents are currently used in epidural catheters to control pain. The potential benefits of this study are to show that one of the epidural sites with these medications may be better at controlling your pain. This will help anesthesia care providers in better controlling postoperative pain.

If you agree to participate in this study you will be one of approximately 60 patients in the study. Random assignment (such as the flip of a coin) will determine which epidural catheter site group you are in. Each group will be monitored by an anesthesia care provider in the surgical intensive care unit, and/or the cardiothoracic ward. You will be assessed at periodic intervals following your surgery as long as an epidural catheter remains in place. Your chart will also be marked with a label identifying you as a study participant.

The epidural catheter that you will receive for your pain control will be inserted just before your surgery begins. The amount of medication you receive will be specific for the medication, the site used, and according to the level of pain that you may be experiencing.

This study is being conducted by graduate students in the U. S. Army Nurse Anesthesia Course under the supervision of a faculty member and the Phase II site director. The epidural catheter will be placed by a staff Anesthesiologist, staff Nurse Anesthetist or student Nurse Anesthetist. The epidural that you will receive is the preferred method of pain control for your surgical procedure. If you participate in this study you will receive either preservative free Morphine in a lumbar epidural or Bupivicaine and Fentanyl in a thoracic epidural. Should you

decide not to participate in this study, you are free to discuss alternatives for your postoperative pain control with your anesthesia provider.

You may terminate participation in this study at anytime per your request. Participation in this study or election not to participate will not alter your surgical or anesthesia care, nor will it alter any future care that you may receive. If at any time it is determined that it is in your best interest not to continue in the study, you will be withdrawn from the study.

Participants in this study are encouraged to ask questions at any time. You may ask your anesthesia provider or you may direct your questions to the principal investigator CPT James Williams (706-787-7005) or co-investigators. If you have any questions about the ethical, legal or social aspects of this study, you should contact the Clinical Investigations Division, Eisenhower Army Medical Center, at (706-787-4273). The results of this study will be provided to you upon request.

This study is subject to approval by the departments of Anesthesia and Clinical Investigations. This study is also subject to approval by the utilization review board at the University of Texas Health Science Center at Houston. In the event of physical injury resulting from the investigational procedures, the extent of medical care provided is limited and will be within the scope authorized by the Department of Defense. Necessary medical care does not include domiciliary (home or nursing home) care.

Any information that you provide in this study that identifies you will remain strictly confidential and will not be disclosed. By signing this consent form you will be giving permission to allow publication of data collected in this study in aggregate form. A copy of this form will be given to you.

I have read the above explanation and agree to participate in the study described. I am aware that information gained from my participation in this study may be published in medical journals, discussed for educational purposes and used to further medical science. I also understand that by participating in this study, I will not be personally identified.

_____ _____

Wintess Initials/Date Volunteer Initials/Date

I do ____ do not____(check one & initial) consent to the inclusion of this form in my outpatient medical treatment record.

SIGNATURE OF VOLUNTEER DATE SIGNATURE OF LEGAL GUARDIAN (if volunteer is a minor)

_____ _____

PERMANENT ADDRESS OF VOLUNTEER TYPED NAME OF WITNESS

_____ _____

SIGNATURE OF WITNESS DATE

REVERSE OF DA FORM 5303-R, MAY 89

APPENDIX F

Epidural Analgesia Study Protocol

Epidural Analgesia Study Protocol

The study subjects will be selected from surgical candidates who present to DDEAMC for a thoracotomy. When the study subjects presents for the anesthesia preoperative interview, options of postoperative analgesia will be discussed to include epidural analgesia. If the study subject consents to an epidural and meets the inclusion criteria of the study, the subject will be informed of the purpose of the study and asked to participate. One of the investigators will meet with each study subject on their day of surgery. The investigator will obtain written informed consent from all patients who agree to participate in the study before they receive any sedative medications. Upon obtaining informed consent, the investigator will randomly remove a card from the study container. This container will contain 30 lumbar epidural cards (L) and 30 thoracic epidural cards (T). After random selection of the epidural card, the patient will be assigned to the corresponding lumbar group (group L) or thoracic group (group T). The selected epidural card will then be placed into an envelope designated "used cards". In addition, the subject will be entered in the epidural study log to identify the subject and the analgesic technique to be implemented. The subject's chart will then be identified with an epidural study protocol label. This label will alert the anesthesia care provider to the epidural placement site and agents to be delivered. An investigator will be assigned to monitor the epidural study folder to ensure that all forms are available and that the protocol is being followed.

Prior to induction of a general anesthetic, the subjects in the lumbar epidural group will receive an epidural catheter placed at the L3 - L4 vertebral interspace plus or minus

one interspace. In the event that the epidural needle enters the subarachnoid space upon insertion, the study subjects will be removed from the study and offered alternative postoperative analgesia options. After the subject is induced and intubated, a bolus of preservative free Morphine 30 - 40 mcg/kg will be administered. In addition, an infusion of preservative free Morphine at .4 - .7 mg/ hr will be started within 30 minutes of the initial bolus.

Prior to induction of a general anesthetic, the subjects in the thoracic epidural group will receive an epidural catheter placed at the T6 - T8 vertebral interspace plus or minus one interspace. In the event that the epidural needle enters the subarachnoid space upon insertion, the study subjects will be removed from the study and offered alternative postoperative analgesia options. After the subject is induced and intubated, a bolus of 0.25% Bupivacaine Hydrochloride 0.1 - .15 cc/kg plus 100mcg of Fentanyl will be delivered to the patient. A maintenance infusion of Bupivacaine Hydrochloride 0.25% plus Fentanyl 5 mcg/cc will then be delivered at an infusion rate of .1 - .15 cc/kg/hr to the patient within 30 minutes of the initial bolus. A maintenance infusion of Bupivacaine Hydrochloride 0.0625% plus Fentanyl 5 mcg/cc at .1 - .15 cc/kg/hr will then be started within 30 minutes of arrival in the SICU or PACU.

DA FORM 4256 pre-printed POST-OPERATIVE EPIDURAL ANALGESIA ORDERS will be generated for each subject receiving an epidural. The study protocol will be attached to each subject's Epidural Analgesic Data Tool. On the day of surgery, the subject will meet with his anesthesia care provider and reconfirm health history, anesthetic plan, and desire to continue

with participation in study. At this time, the subject will receive their assigned epidural as determined by previous randomization. The catheter will be placed using either the "loss of resistance" or "hanging drop" technique with a midline or paramedian approach. Following a standard test dose via the epidural, patients will be induced and intubated. All subjects will receive inhalation anesthetics and intravenous narcotics during surgery dependent on practitioner preference and patient condition. Narcotics administered during the case will include Fentanyl (up to) 5 ug/kg/hr, Sufentanil (up to) 0.5ug/kg/hr, morphine (up to) 0.15 mg/kg/hr.

Following thoracotomy, the subject will be admitted to the PACU, SICU, or Cardiothoracic ward. Assigned staff will be informed of the subjects participation in the study via chart sticker identification. Staff will be instructed to record epidural data on epidural flowsheet (EAMC OP 552) per unit protocol. An anesthesia care provider will be available 24 hours a day to provide additional analgesia as needed. Supplemental medications available to the subject will include those listed on Postoperative Epidural Analgesia Orders (DA form 4256).

APPENDIX G

Abbreviated Epidural Analgesia Study Protocol

Epidural Analgesia Study Protocol

Lumbar		**Thoracic**
L 3- L 4 +/- 1 Interspace	**(INTRAOP)**	T 6 –T 8 +/- 1 Interspace
BOLUS		BOLUS
30-40 mcg/kg P.F. Morphine	**Induction/Intubation**	100 ug. Fentanyl Plus 0.25% Bupivacaine (.1 - .15 cc/kg)
⇩	**Thoracic Procedure** ⇩	⇩
INFUSION P.F. Morphine (0.4 - 0.7 mg/hr)	**(INTRA OP)**	INFUSION 0.25% Bupivacaine & 5 ug/cc Fentanyl (.1 - .15 cc/kg)
Continue infusion	**POST OP**	INFUSION 0.0625% Bupivacaine Plus 5 ug/cc Fentanyl (.1 - .15 cc/kg/hr)

SUGGESTED POSTOPERATIVE PROTOCOL FOR INADEQUATE EPIDURAL PAIN RELIEF

1. EPIDURAL BOLUS AND INCREASE RATE
   IF INADEQUATE, THEN
2. REPEAT EPIDURAL BOLUS AND INCREASE RATE
   IF INADEQUATE, THEN
3. MORPHINE SULFATE, 2 - 4 mg I.V.
   IF INADEQUATE, THEN
4. REPEAT MORPHINE SULFATE
   IF INADEQUATE, THEN
5. CONSULT ON THE POTENTIAL FOR DISCONTINUING THE EPIDURAL INFUSION AND STARTING ON PATIENT CONTROLLED ANALGESIA

APPENDIX H

Post Operative Epidural Analgesia Orders

POST OPERATIVE EPIDURAL ANALGESIA ORDERS

1. Initial dose _____ at _____
(time & date)

2. EPIDURAL SOLUTIONS (circle choice):

a. MS04 (preservative free PF) 0.1 mg/cc;
Volume 200cc; Rate _____cc/hr.

b. Bupivicaine (PF) 0.0625% w/Fentanyl
5mcg/cc; Volume 200cc; Rate_____cc/hr.

c. Epidural PCA Mode (not w/MS04)
_____cc; Lockout interval_____min
Combined hourly rate not to exceed 15cc/hr.

3. ADDITONAL ANALGESIA (circle choice):

a. Epidural bolus dose (not w/MS04)
_____cc for breakthrough pain, then

b. Increase infusion rate by _____cc/hr
above previous rate

c. If pain not relieved, may repeat (a) and
(b) above in _____min

d. MS04 2-4mg IV q2 hrs prn pain

e. Toradol _____mg IM/IV q6 hrs prn

4. SUPPLEMENTAL ORDERS (circle choice):

a. For Nausea, Reglan 10 mg IV q6 hrs prn x 2 doses

b. For Nausea, Narcan 20mcg IV q20min prn x 3 doses

c. For Pruritis Benadryl 12.5-25mg IV q20 min prn x 2 doses

d. For Pruritis Narcan 20mcg IV q20 min prn x 3 doses

5. No other standing Narcotic orders (IV, IM or SQ) or other sedating medications except by Anesthesia Pain Service.

POST OPERATIVE EPIDURAL ANALGESIA ORDERS
Continued

6. Narcan ampule (0.4mg), needle, and 10cc syringe at bedside.

7. Vital signs q4 hours, Respiratory rate q1 hour for 24 hrs then q4 hrs and record on epidural flowsheet. Record pain/ sedation score on epidural flowsheet q1 hour while awake x 24 hrs, then q4 hrs. Inspect catheter and insertion site q shift and notify anesthesia for problems.

8. If Respiratory Rate <8/min, turn off infusion and notify house officer and Anesthesia IMMEDIATELY.

9. Notify House Officer for temp >101F or no void >8 hours.

10. Notify Anesthesia for inadequate analgesia, excessive sedation, refractory side effects or any problems with infusion or catheter.

Beeper _____ or 787-7632/1104/1910.

11. Place Heparin lock and flush q shift while epidural in place.

12. Spinal narcotic precaution sign posted at bedside for duration of epidural infusion.

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Vitae

Captain James Russell Williams was born in Xenia, Ohio on 15 December 1963. He is the son of Jerry Kenneth Williams and Dollie Rose Williams. After completing his work at Xenia High School, Xenia, Ohio in 1982, he enlisted in the United States Air Force. During the following five years, he served as an operating room technician at Wright Patterson Air Force Base, Dayton, Ohio and the United States Air Force Academy, Colorado Springs, Colorado. In September 1987, he entered Sinclair Community College in Dayton, Ohio. He received the degree of Associate of Science in Nursing from Sinclair Community College in June 1989. During the following four years, he was employed as a critical care nurse at Kettering Medical Center, Kettering, Ohio and Good Samaritan Hospital, Dayton, Ohio. In September 1992, he entered Andrews University in Kettering, Ohio. He received the degree Bachelors of Science in Nursing from Andrews College in June 1994. During the following two years he was employed as a post anesthesia care nurse at Dwight David Eisenhower Army Medical Center, Fort Gordon, Georgia. In July 1996, he entered the U.S. Army/University of Texas Health Science Center at Houston graduate program in anesthesia nursing, Fort Sam Houston, Texas. He has been married to Tamara Kay Carmack of Bluffton, Ohio since 1989. They have two daughters, Kami Nicole, age 13 and Audre Rebeckah, age 8.

Captain David Lee Hoehn was born in St. Louis, Missouri on 04 August 1962. He is the son of Dr. Lilburn Paul Hoehn and Sallie Lou Hoehn. After completing his work at Beavercreek High School, Beavercreek, Ohio in 1980, he became a volunteer and part-time Firefighter/Paramedic with the Beavercreek Fire Department, Beavercreek, Ohio. During the following ten years, he worked as a paramedic while attending college part-time. He joined the Ohio Army National Guard in 1986 as a combat medic. In March 1992, he graduated from Sinclair Community College, Dayton, Ohio with the degree of Associate of Science in Nursing. During the following two and one half years, he was employed as an intensive care nurse at Miami Valley Hospital, Dayton, Ohio. In September 1992, he entered Andrews University in Kettering, Ohio. He received the degree Bachelors of Science in Nursing from Andrews College in June 1994. During the following two years he was employed as a open heart recovery/intensive care nurse at Dwight David Eisenhower Army Medical Center, Fort Gordon, Georgia. In July 1996, he entered the U.S. Army/University of Texas Health Science Center at Houston graduate program in anesthesia nursing, Fort Sam Houston, Texas. He has been married to Elaine Kim Solgan of Dayton, Ohio since 1989. They have two daughters, Taylor Nicole, age 6 and Caitlin Danielle, age 5.

This thesis was typed by the investigators.